BARRIERS TO RECYCLING
OF
HAZARDOUS WASTE

CCREM-TS/WM-TRE001 JUNE 1988

Canadian Council of Resource and Environment Ministers

Le Conseil canadien des ministres des ressources et de l'environnement

89-04227/

BARRIERS TO RECYCLING OF HAZARDOUS WASTE

FOR
CANADIAN COUNCIL OF RESOURCE & ENVIRONMENT MINISTERS

TECHNOLOGY RESOURCE INC.
WEST VANCOUVER, B.C.

JUNE 1988

Canadian Cataloguing in Publication Data
Main entry under title:
Barriers to recycling of hazardous waste

"CCREM-TS/WM-TRE001"
Executive summary in French
ISBN 0-7726-0912-8

1. Hazardous wastes - Government policy - Canada.
2. Recycling (Waste, etc.) - Government policy - Canada. I. Canadian Council of Resource and Environment Ministers. II. Technology Resource Inc.

TD811.5.B37 1988 363.7'28 C89-092046-X

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MESURE 7.1 - OBSTACLES AU RECYCLAGE DES DÉCHETS DANGEREUX

En décembre 1987, le Conseil canadien des ministres des Ressources et de l'Environnement a commandé une étude des obstacles qui s'opposent au recyclage des déchets dangereux au Canada. L'object et de l'étude était:

- d'identifier les secteurs industriels producteurs de déchets dangereux;
- de déterminer les obstacles économiques, juridiques, techniques et d'organisation qui s'opposent au recyclage des déchets dangereux;
- de cerner et d'évaluer les encouragements économiques du recyclage de ces déchets;
- de recommander des politiques et des mesures qui, dans l'administration publique et l'industrie, stimuleraient le recyclage des déchets dangereux.

Ces objectifs ont été atteints grâce à un dépouillement en long et en large des publications actuelles, à l'étude des lois en vigueur au Canada, à l'examen des programmes de réduction du volume des déchets dangereux et de leur recyclage, qui ont fait leurs preuves aux États-Unis, en Europe et dans d'autres régions du monde, et grâce à des interviews de législateurs et d'autres personnes.

Les Principales conclusions de l'étude peuvent se résumer comme suit:

- Les principaux obstacles au recyclage des déchets dangereux sont économiques. Les plus importants sont le fait que les coûts de l'élimination sont inferieurs à ceux du recyclage; que les investissements sont très risqués et d'un rendement faible pour les recycleurs; que le volume de déchets disponibles ainsi que le marché des matières recyclées sont petits.

- Les techniques actuelles permettent la récupération et le recyclage de plusieurs types de déchets. Malgré cela, il se peut qu'il ne soit pas économique de recycler un certain nombre de déchets inorganiques tels que les acides et les bases.
- L'attitude des consommateurs à l'égard de l'industrie du recyclage en général ainsi que la qualité inférieure qu'on prête aux produits reyclés sont de gros obstacles au recyclage des déchets dangereux.

- Plusieurs des programmes de réduction du volume des déchets dangereux qui ont été lancés par de grandes sociétés américaines et qui ont fait leurs preuves comprennent comme éléments: un fort appui et l'encouragement de la haute direction sous la forme de politiques et de mesures; la réduction des coûts ou les profits avérés de la réduction des déchets; la réduction de la responsabilité à long terme de l'entreprise découlant des déchets dangereux; des systèmes internes d'information pour traquer les matières excédentaires qui peuvent être disponibles pour d'autres divisions de l'entreprise; le partage de la responsabilité de réduire la production de déchets dangereux entre tous les échelons de l'entreprise; des programmes lancés à la grandeur de l'entreprise pour promouvoir la réduction des déchets dangereux.
- Les meilleures occasions de s'attaquer aux déchets dangereux se présentent dans les installations productrices et, souvent, elles s'accompagnent d'avantages économiques nets.

Aux États-Unis et dans quelques grandes sociétés canadiennes, la tendance est de mettre sur pied des programmes de réduction du volume des déchets. Celle-ci est possible par la récupération des matières et leur réutilisation directe ou par leur réduction à la

source grâce au remplacement des matières premières, à la modification des procédés, à la reformulation des produits et au recyclage sur place.

Il est recommandé que le CCMRE adopte une politique de réduction du volume des déchets dangereux. Par cette politique, l'industrie serait fortement encouragée à chercher des moyens de réduire au minimum la production de ces déchets. Le CCMRE et chacun de ces membres devrait encourager des programmes de mise au point et de transfert des techniques. Cette politique devrait être mise en oeuvre le plus tôt possible.

EXECUTIVE SUMMARY

In December, 1987, the Canadian Council of Resource and Environment Ministers commissioned a review of the barriers to recycling of hazardous waste in Canada. The objectives of the study were as follows:

- to identify those industrial sectors which generate hazardous waste;
- to identify economic, legislative, technological, and corporate/institutional barriers to recycling of hazardous waste;
- to identify and evaluate economic incentives to promote recycling of hazardous waste;
- to recommend policies and actions by government and industry which will stimulate recycling of hazardous waste.

These objectives were accomplished through an extensive review of existing literature, review of current legislation in Canada, review of successful hazardous waste recycling and minimization programs in the U.S., Europe and other areas of the world, and interviews with legislators and others.

The major findings of the study can be summarized as follows:

- The major barriers to the recycling of hazardous waste are economic in nature. The most important barriers are: costs for disposal are lower than to recycle; investment risk is high and payback is low for recycling facilities; and the volume of available waste material and market for recycled materials are small.
- Current technology is capable of recovery and recycle of several types of waste. Although the technology may be available, it may not be economically feasible to recycle a number of inorganic wastes such as acids and caustic materials.
- Consumer attitudes towards the recycling industry in general and the perceived inferior quality of recycled products are major barriers to recycling of hazardous wastes.
- The elements of several successful hazardous waste minimization programs undertaken by major U.S. companies include: strong senior management support and incentive through policies and actions; a

- demonstrated reduction in costs or generation of profit from waste minimization; a decrease in long-term corporate liability associated with hazardous waste; in-house information systems to identify surplus materials which are available to other divisions; a sharing of responsibility for hazardous waste reduction at all levels of the company; and company-wide programs to promote awareness of measures to reduce hazardous waste generation.

- ♦ The best opportunities for hazardous waste reduction occur within the facilities where they are generated, often with a net economic benefit.

Trends in the U.S. and in some major Canadian companies are to establish waste minimization programs. Waste minimization can be achieved by recovery and direct re-use of materials, source reduction by raw material substitution, process change or product reformulation and on-site recycling.

It is recommended that a hazardous waste minimization policy be adopted by CCREM. The policy should strongly encourage industry to search for ways to minimize hazardous waste generation. Technology development and technology transfer programs should be promoted by CCREM and each participating government. The waste minimization policy should be implemented at the earliest possible date.

BARRIERS TO RECYCLING OF HAZARDOUS WASTE

EXECUTIVE SUMMARY

1. This report examines the barriers to recycling of hazardous waste. In preparing this report, we have employed a broad definition of recycling to ensure that all technologies and opportunities for hazardous waste reduction have been included. Consequently, we have examined both on-site and off-site recycling operations, process modifications, raw material substitution and other means of reducing hazardous waste.

2. Barriers to hazardous waste recycling (minimization) were identified in six major categories, including: economic or financial, technological, legislative, institutional, attitudinal, and informational. The barriers under each of these categories are summarized in Table ES-1.

3. The barriers under each of the categories have been ranked in order to identify areas where efforts should be concentrated. In completing this ranking, we found that the economic barriers were of greatest importance. Attitudinal barriers were ranked second, primarily due to the fear that recycled materials are inconsistent or unreliable and/or the risk associated with the perception of product quality for materials manufactured from recycled hazardous waste. Legislative barriers were ranked of least importance.

4. The most important barriers to recycling of hazardous waste include the following:

   - lower cost disposal alternatives to recycling;
   - high investment risk with low payback;
   - small volume of raw material and small market for recycled material.

   These barriers are inter-related. If the true cost of disposal were charged for hazardous wastes, more material would be available for recycling. If more material is available for recycling, investment risk decreases. One additional factor, which is of lesser significant at the present time, will

become a significant variable in the equation when larger volumes of material become available for recycling. The re-sale price of recycled material must be competitive with the price for virgin materials of the same quality.

5. We have examined several successful hazardous waste minimization programs undertaken by major U.S. companies. The elements of these programs which contributed to their success were identified and include the following:

- ♦ strong support and incentive provided by the policies and actions of senior management;
- ♦ the ability of the programs to reduce costs and, in some cases, to generate a profit;
- ♦ the ability of the programs to decrease the long-term risks associated with liability for hazardous wastes;
- ♦ a sharing of the responsibility for hazardous waste reduction among all levels and operating divisions of the company;
- ♦ consideration of all waste reduction measures, from source reduction to end-of-pipe alternatives;
- ♦ establishment of company-wide programs to promote awareness and acceptance of hazardous waste reduction measures;
- ♦ establishment of information systems to identify surplus materials available for use throughout the company.

6. In our opinion, the best opportunities for hazardous waste reduction occur within the facilities of the manufacturer or generator rather than with off-site recycling. There is often an opportunity for the manufacturer to **reduce production costs** and **contribute to the overall profitability** through a combination of in-process technologies and raw material substitutions.

7. We strongly recommend that a national hazardous waste minimization plan be developed to provide support and direction to the CCREM policy to reduce quantities of hazardous waste for treatment and disposal.

8. We recommend that a set of goals and objectives be established as a prerequisite to the development of a national hazardous waste minimization plan.

9. We recommend that policies and programs be implemented to overcome the major economic barriers to recycling of hazardous waste. Further investigation is necessary to identify the most effective means to improve the cost competitive position of recycling over disposal. A variable which may become more significant is the market price of recycled product. The effect of this variable should be fully evaluated in any further studies.

10. We recommend that steps be taken by CCREM to establish procedures and protocols for industry to implement a hazardous waste minimization plan within each facility.

11. We recommend that technology transfer and technology development be included in each province to promote hazardous waste minimization.

12. We recommend that several projects be undertaken or sponsored by government to demonstrate the viability and profitability of waste minimization to industry.

13. We recommend that the national hazardous waste minimization plan or associated programs concentrate efforts in terms of geographic regions and industry sectors and possibly specific industries where hazardous waste minimization can be most effective.

14. We recommend that appropriate economic incentives and financial assistance be made available to industries for waste minimization programs.

15. We recommend that governments work closely with senior corporate management to ensure that hazardous waste minimization is a priority at all corporate levels.

16. We recommend that national policies, regulations and strategies be developed to encourage waste minimization and recycle as a first option.

17. We recommend that a hazardous waste management strategy be developed and implemented as a policy of the federal government and each provincial government.

18. We recommend that the necessary studies and planning commence at the earliest possible date to implement the national hazardous waste minimization plan.

Table ES-1

CATEGORIES OF BARRIERS TO HAZARDOUS WASTE RECYCLING

ECONOMIC BARRIERS

- Current cost of treatment, transportation and disposal.
- Low current cost of virgin raw materials.
- Lack of volume markets.
- Lack of adequate incentives such as tax breaks, subsidies, low interest bonds, and favourable fee structures.
- Cost of implementing recycling practices.
- Risk of investment/uncertainty of payback.

TECHNOLOGICAL BARRIERS

- Restricted exchange of technical information restricted due to perceived loss of market advantage.
- Waste quantity not suited to available technologies.
- Waste composition not suited to available technologies.
- Suitable technology not available, yields product of too low quality.
- Off-site technologies not available.
- Technologies are highly waste stream specific.
- Recycling is not the most efficient waste reduction technology for some wastes.
- Recycling technology may not be compatible with production process.
- Raw material specifications too stringent for recycled waste.
- Risk associated with redesign of manufacturing process.

LEGISLATIVE BARRIERS

- Lack of appropriate legislative mandates.
- Lack of legislative incentives or disincentives.
- Implication of inadequate pollution control standards.
- Inadequate or inconsistent monitoring of existing standards.
- Lack of onus for industry and commerce to recycle.
- Protective provisions for virgin materials, waste purity, product confidentiality, and liability.
- Definitions of hazardous waste.
- Establishment of liability for hazardous wastes.

INFORMATIONAL BARRIERS

- Lack of available technological information on recycling methods and applicability.
- Lack of available information on economic incentives.
- Lack of available information on potential returns of recycling.
- Lack of information among consumers on value of recycling in hazardous waste reduction.
- Lack of information on availability of audits, exchanges, information programs.

Table ES-1 (cont.)

CATEGORIES OF BARRIERS TO HAZARDOUS WASTE RECYCLING

ATTITUDINAL BARRIERS

- Pollution control not financially productive, especially in development.
- Desire to uphold traditional practices.
- Fear that recycled goods will lower perception of product quality.
- Potential liability for recycled materials.
- Impression that recycled wastes are unreliable, inconsistent.

INSTITUTIONAL BARRIERS

- Vertical integration of industries.
- Existing waste management practices.
- Product quality and raw material procurement specifications.
- Company size and resources.
- Lack of communication between production line and management.
- Lack of knowledge regarding wastes generated or products used.

BARRIERS TO RECYCLING OF HAZARDOUS WASTE

1.0 INTRODUCTION

Technology Resource Inc. has been requested by the B.C. Ministry of Environment to identify and evaluate barriers to the recycling of hazardous waste. The project is part of the National Hazardous Waste Action Plan being implemented by the Canadian Council of Resource and Environment Ministers (CCREM). One of the key objectives of this National Plan is to reduce the quantities of hazardous waste requiring treatment and disposal. Several barriers to the recovery, recycle and/or reuse of hazardous wastes are known to exist. For the purposes of this project, these barriers have been categorized under the following categories:

- Economic;
- Technological;
- Legislative;
- Informational.
- Attitudinal;
- Institutional.

Barriers and incentives to minimize hazardous waste generation by recycling, recovery, reuse and other means are discussed in the remainder of this report.

In preparing our report, we have undertaken an extensive review of existing literature and data to identify the major barriers. Each of these barriers has been carefully evaluated and is discussed in terms of the reasons for their existence and the means in which to overcome these barriers. Our discussions are based largely on the experiences in other countries, particularly the U.S., France and Germany. Finally, we provide recommendations to overcome or minimize barriers to recycle, recover and reuse hazardous wastes in Canada.

1.1 Scope of the Work

Several specific tasks were undertaken in this study. These tasks are summarized below:

- adopt a definition of hazardous waste to be used in the context of this project which is consistent with the provincial and national hazardous (special) wastes;
- identify hazardous waste generating industrial sectors in the Canadian economy so that barriers and incentives can be evaluated in perspective of the quantities of waste generated, industrial processes and other unique features;
- identify the economic barriers to hazardous waste recovery and recycle;
- identify and evaluate economic incentives which may enhance hazardous waste recovery and recycle;
- examine and evaluate the effect of corporate policy, corporate structure and other institutional economic effects on hazardous waste recovery and recycle;
- review existing and proposed legislation at the federal, provincial and municipal levels which may enhance or detract from hazardous waste recovery and recycle;
- establish technical limitations to the recovery and recycle of hazardous wastes based on both industrial process and waste treatment recovery;
- identify and recommend policies and actions of government and industry which will enhance hazardous waste recovery and recycle.

1.2 Definitions

Several of the terms to be used in this report may have different meanings to different people. For example, definitions of **"hazardous waste"** vary from jurisdiction to jurisdiction, statute to statute, and region to region. In certain cases, hazardous waste is considered to be comprised primarily of toxic waste. In other cases, a broader definition is used. Consequently, this section of our report will define several terms used throughout the report for clarity and continuity.

Based on regulations in Canada, hazardous (special) wastes are defined slightly differently within each province. For example, in British Columbia, "special waste" means

(a) dangerous goods that are no longer used for their original purpose and that are
    (i) recyclable materials, or
    (ii) that are intended for treatment or disposal, including storage before treatment or disposal,
    but does not include dangerous goods that are
    (iii) refuse that is collected by or on behalf of a municipality from residential premises,
    (iv) sewage, or
    (v) defective or otherwise not usable for the intended purpose and that are in the process of being returned directly to the manufacturer or to the supplier, or
    (vi) included in CLASS 7 of the Federal Regulations,
(b) waste oil,
(c) waste asbestos,
(d) waste pest control product containers and wastes containing pest control products, and
(e) leachable waste.

In contrast, Regulation 309 under the Ontario Environmental Protection Act defines "hazardous waste" as a waste that is

i. hazardous industrial waste,
ii. acute hazardous waste chemical,
iii. hazardous waste chemical,
iv. severely toxic waste,
v. ignitable waste,
vi. corrosive waste,
vii. reactive waste,
viii. radioactive waste except radioisotope wastes disposed of in a landfilling site in accordance with the written instructions of the Atomic Energy Control Board,
ix. pathological waste,
x. leachate toxic waste, or
xi. PCB waste as defined in Ontario Regulation 11/82,

and includes a mixture of acute hazardous waste chemical, hazardous waste chemical, hazardous industrial waste, pathological waste, radioactive waste or severely toxic waste and any other waste material, but does not include

xii. hauled sewage,
xiii. waste from the operation of a sewage works subject to the Ontario Water Resources Act where the works,
    A. is owned by a municipality,
    B. is owned by the Crown subject to an agreement with a municipality under the Ontario Water Resources Act, or
    C. receives only waste similar in character to the domestic sewage from a household,
xiv. domestic waste,

xv. ash resulting from the incineration of domestic waste or other waste of a similar nature,

xvi. waste that is a hazardous industrial waste, hazardous waste chemical, ignitable waste, corrosive waste, leachate toxic waste or reactive waste and that is produced in any month in an amount less than five kilograms or otherwise accumulated in an amount less than five kilograms,

xvii. waste that is an acute hazardous waste chemical and that is produced in any month in an amount less than one kilogram or other accumulated in an amount less than one kilogram,

xviii. an empty container or the liner from an empty container that contained hazardous industrial waste, hazardous waste chemical, ignitable waste, corrosive waste, leachate toxic waste or reactive waste,

xix. an empty container of less than twenty litres capacity or one or more liners weighing, in total, less than ten kilograms from empty containers, that contained acute hazardous waste chemical,

xx. the residues or contaminated materials from the clean-up of a spill of less than five kilograms of waste that is a hazardous industrial waste, hazardous waste chemical, ignitable waste, corrosive waste, leachate toxic waste or reactive waste, or

xxi. the residues or contaminated materials from the clean-up of a spill of less than one kilogram of waste that is an acute hazardous waste chemical.

Although hazardous (special) wastes generally include the same materials from province to province, there are notable differences. For the purposes of the present study, it is necessary to adopt a general definition which will permit a clear discussion in terms of recyclable materials. We have made no attempt to specify specific properties or minimal quantities or sources of wastes in our definition. For the purposes of our study, hazardous wastes are those which contain or are composed of the following materials:

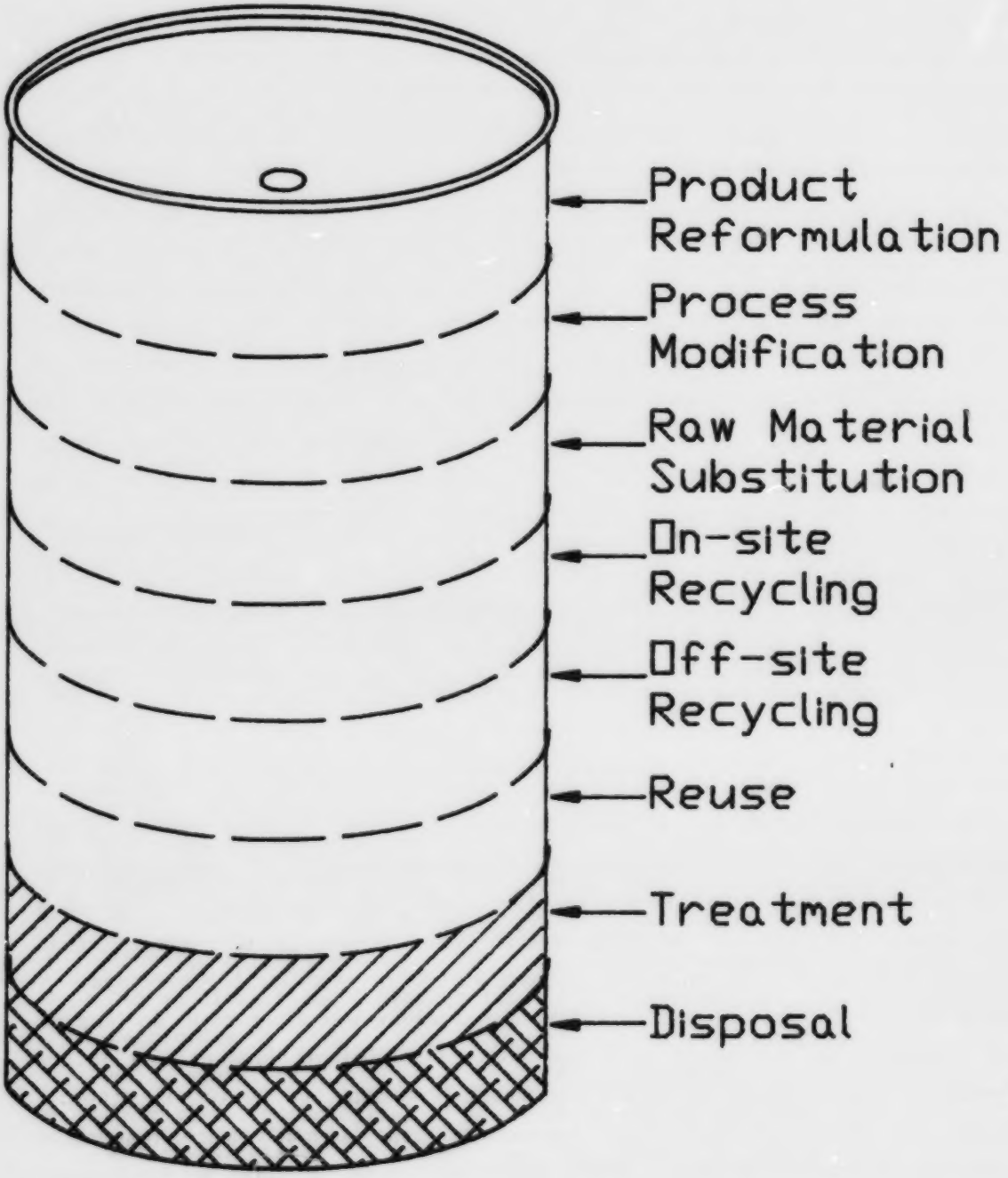
- non-halogenated solvents
- halogenated solvents
- phenolics
- aromatic polycyclics
- PCB's, dioxins and dibenzofurans
- pesticides
- oils, emulsions
- infectious, pathological and tissue wastes
- lab packs
- still bottoms, sludges and residues
- other organics
- heavy metals
- corrosive materials
- cyanides
- radioactive materials
- other inorganics

Hazardous waste management and associated activities also require clarification and definition. "Hazardous waste management" includes all activities associated with the transportation, treatment, recycle, recovery, disposal of materials deemed to be hazardous waste. The hazardous waste stream is illustrated schematically in Figure 1-1 for activities other than transportation. Thus, a fraction of the hazardous waste stream may be isolated, recovered or recycled internally in the plant or process from which it came. In certain instances, hazardous waste can be eliminated altogether by product reformulation, raw material substitution and/or process modification. Alternatively, a third fraction of the hazardous waste may be recovered and recycled, either on the site of hazardous waste generation or off-site at external facilities. A fourth fraction of the hazardous waste may be redirected to generation of energy or recovery of materials. A fifth fraction may undergo treatment involving volume reduction, detoxification or other alteration of properties. Following treatment, the reduced volume of this waste stream will be directed to a secure landfill for final disposal. And finally, a fraction of the hazardous waste stream will go directly to a secure landfill for final disposal. Clearly, several of these pathways lead to a waste reduction, consistent with the stated policy of the National Hazardous Waste Action Plan, and others do not entail any net reduction in total waste.

Several additional terms relating to waste reduction have been used in Canada and the U.S.

Hazardous waste minimization is a term used by the Hazardous Waste Engineering Research Laboratory of the U.S. EPA. As used by this agency "waste minimization" means "the reduction to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as the reduction is consistent with the goal of minimizing present and future threats to human health and the environment (Freeman, 1987). On the other hand, the Office of Technology Assessment uses a much more restrictive definition of **waste reduction**. "Waste reduction" means "in-plant practices that

Figure 1-1: Hazardous Waste Reduction Options



reduce, avoid or eliminate the generation of hazardous waste so as to reduce risks to health and environment. Any actions undertaken at a location separate from the waste generating activity, including waste recycling or treatment of wastes after they are generated, are not considered waste reduction. Also, an action that merely concentrates the hazardous content of a waste to reduce volume or dilutes it to reduce the degree of hazard is not considered waste reduction. This definition is meant to be consistent with the goal of preventing the generation of waste at its source rather than controlling, treating or managing waste after its generation." (OTA, 1986)

There clearly are several definitions which can be applied to recycling or reduction of hazardous waste. For this report, we define **"recycling activities"** to be "those which lead to direct in-process reuse, on-site or off-site recovery and recycle of materials, and recovery for energy or materials." Although this definition is somewhat broader than normally applied to recycle activities, it allows us to discuss options associated with recovery and reuse of materials deemed to be hazardous waste.

2.0 WASTE GENERATORS AND WASTE STREAMS

Industry generates hazardous waste at rates related to specific manufacturing activities and the materials used. In order to focus on priority issues and areas where efforts may be most fruitful, it may be useful to identify the rates of generation of hazardous waste by type and by industry sector. In this regard, a number of surveys have been undertaken and completed in Canada, including inventories by Gore and Storrie (1982), and by Reid Crowther and Partners (1981). Similar estimates for wastes regulated under the Resource Conservation and Recovery Act (RCRA) in the U.S. have also been compiled (Freeman and Eby, 1987). Relative quantities of hazardous waste by Standard Industry Classification (SIC) are presented in Table 2-1 for each of the above-quoted studies. As can be seen, there are similarities in the percent wastes generated by industry sector. There are significant differences from study to study, however, which may be attributable to the way in which hazardous wastes were defined, differences in industry mix or differences in the methodology to complete the inventory. Reid Crowther's (1981) estimates differ from the others primarily due to the regional nature of the inventory and the relatively young nature of the manufacturing industry in the region of the survey.

The rates of hazardous waste generation are clearly dominated by the chemical and allied products sector both in Canada and the U.S. A substantial volume of hazardous waste is also generated by the refined petroleum and coal products, primary metals and fabricated metal products sectors. Manufacture of rubber and plastics products also generates a notable volume of hazardous waste in the U.S. Values for hazardous waste from this sector are not available for Canada. Clearly, the majority of hazardous wastes (75 - 95%) can be accounted for within these five industry sectors.

A very crude approximation of hazardous waste by waste type is shown in Table 2-2. Based on data for Western Canada (Reid Crowther, 1981), ignitable or combustible wastes form a substantial fraction of the waste stream. The quantity of ignitables for the U.S. is substantially lower, possibly reflecting a

Table 2-1

HAZARDOUS WASTE GENERATED BY INDUSTRY SECTOR

SIC	Industry Sector	Hazardous Waste Generation		
		Canada*	Western Canada**	U.S.A.***
			Percent	
28	Chemical & Allied Products	46.80	16	47.9
29	Refined Petroleum & Coal Products	8.10	50	11.8
30	Rubber & Plastic Products			5.5
31	Leather & Allied Products	0.50		
32	Non-Metallic Mineral Products	0.02		
33	Primary Metals	15.30	8	18.0
34	Fabricated Metal Products	7.10		9.6
35	Non-Electrical Machinery	.08		1.8
36	Electric & Electronic Machinery	.09		0.7
37	Transportation Equipment	.03		1.1
	Wood Preserving			
	Miscellaneous Manufacturing			

* Data from Gore & Storrie, 1982 (inventory of all industry sectors not completed)

** Data from Reid Crowther and Partners, 1981 (inventory of all industry sectors not completed)

*** Data from Freeman & Eby, 1987

Table 2-2

PROFILE OF HAZARDOUS WASTES BY PROPERTIES

Region	Hazardous Waste by Property				
	Ignitables	Corrosives	Toxins	Reactives	Other
	Percent				
Canada [a]		46.8*	38.4**		14.9
Western Canada [b]	35.5	31.0	1.0		15.0
U.S.A. [c]	0.9	41.0	10.0	48.1	

* wastes classed as chemicals

** wastes classed as metals

a. Gore & Storrie, 1982
b. Reid Crowther and Partners, 1981
c. Freeman and Eby, 1987

large quantity of these wastes being redirected or recycled for energy generation. Unfortunately, it is not possible to make a direct comparison of the data in this table because waste streams have not been defined in the same way. Approaches to minimize treatment and land disposal of hazards will depend on the wastes which can be recovered and recycled.

2.1 Recoverable and/or Recyclable Hazardous Wastes

As can be seen from Figure 2-1, there are a variety of processes and approaches to manage hazardous wastes. Several of these result in reduction of the total hazardous waste stream. Among these waste reduction or minimization approaches, several include various forms of recycling of wastes. Thus the following specific opportunities for waste reduction by recycle can be envisioned:

- direct reuse or recycle of specific waste streams in the manufacturing process from which they originated; (This may require redesign of the process and often shows a good rate of return because there is a reduced raw material consumption, a reduction in hazardous waste treatment and disposal cost, more efficient manufacturing processes, etc.)
- recovery/isolation and recycling of wastes on site; (This may include purification for reuse in plant processes or for reuse in other related processes.)
- off-site recovery/isolation and recycle of waste streams resulting in either off-site resale or return to the plant site for reuse;
- recovery and reuse of waste products for energy generation.

In this context, a number of waste streams can be successfully recycled. The potential successful recycle of several types of hazardous waste are listed in Table 2-3. Factors affecting the success of such recycle will be discussed in detail in Section 4.0, Existing Technology.

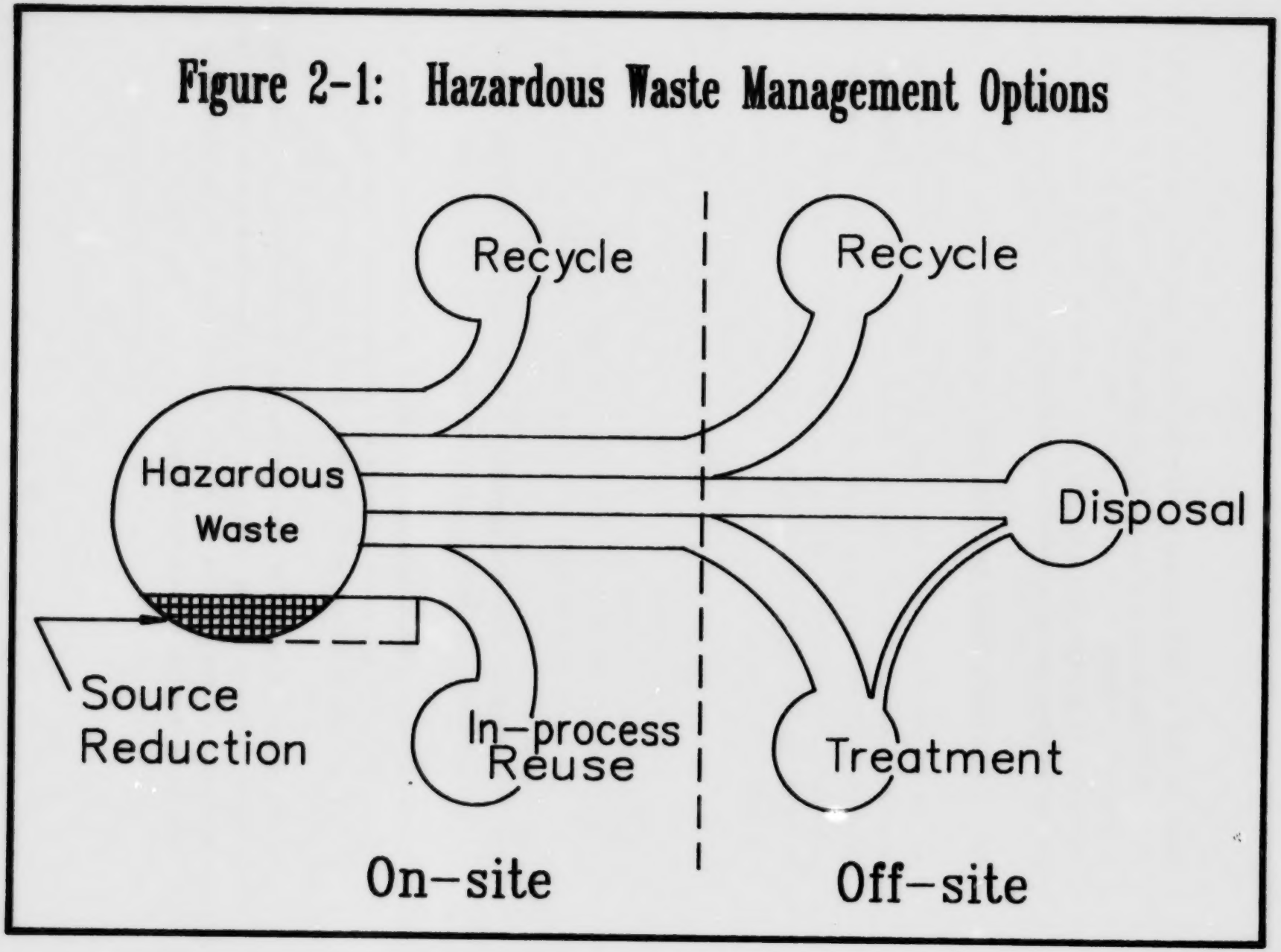


Figure 2-1: Hazardous Waste Management Options
Recycle
Recycle
Hazardous
Waste
Disposal
Source
Reduction
In-process
Reuse
Treatment
On-site
Off-site

Table 2-3

SUMMARY OF RESOURCE AND ENERGY RECOVERY POTENTIAL FOR HAZARDOUS WASTES (ORGANIC)

Type of Waste	Direct Recovery or Reuse	Raw Material for Secondary Use	Energy Recovery	Use as Reagent in Pollution Control	Low Potential for Recovery
Concentrated liquids					
Clean, halogenated	X	X	X		
Clean, nonhalogen.	X	X	X		
Clean, solv. mixtures	X	X	X		
Dirty, halogenated	X	X	X		
Dirty, nonhalogen.	X	X	X		
Dirty, solv. mixtures	X	X	X		
Dilute aqueous wastes					
Readily oxidized, halog.				X	
Readily oxidized, nonhalog.				X	
Difficult to oxid., halog.				X	
Difficult to oxid., nonhalog.					X
Organic solids					
Salts and other solids	X	X			
Tars and residues			X		
Sludges	X		X		
Organic gases/vapours					
Combustible			X		
Special wastes					
Strong oxidizing agents					X
Explosives					X
Biological wastes					X

.... cont

Table 2-3 (cont.)

SUMMARY OF RESOURCE AND ENERGY RECOVERY POTENTIAL FOR HAZARDOUS WASTES (INORGANIC)

Type of Waste	Direct Recovery or Reuse	Raw Material for Secondary Use	Energy Recovery	Use as Reagent in Pollution Control	Low Potential for Recovery
Acid soln.-no contamin.	X	X		X	
Acid soln.-with metals					
Heavy metals (except Cr)	X	X			
Chromium	X				
Noble metals	X				
Pickle liquor	X	X		X	
Acid soln.-with org.					
Emulsified org.		X	X		
Dissolved org.	X	X			
Acid sludges					
Inert solids					X
Solids with metals	X				
Organic solids					X
Acid gases				X	
Alk. soln.-with metals	X	X		X	
Alk. soln. with org.	X	X	X		
Cyanide soln.					X
Cleaning soln.					X
Alkaline sludges					
Inert solids					X
Solids with metals	X				
Organic solids					X
Salt solutions					X
Solids					X
Metals					
Heavy metals	X				
Alkali metals					X
Volatile metals	X	X			
Non-metals					
Phos. sulf. compds.	X				
Asbestos					X

* Used for pH adjustment or similar purpose.

SOURCE: "Technology for Managing Hazardous Wastes", N.Y. State Environmental Facilities Corp., 1979, as cited in Noll et al, 1986.

Selection of a broad definition of recycling ensures that:

- the technology is consistent with waste minimization procedures of the U.S. Environmental Protection Agency and of the recommended waste reduction approaches recommended by the U.S. Office of Technology Assessment;
- there is an opportunity to address all waste streams and waste reduction options;
- there is a procedure whereby several options can be reviewed to select the optimum solution for each site.

3.0 WASTE MINIMIZATION PROGRAMS

3.1 Waste Minimization Programs in Industry

As defined in Section 1, waste minimization can include any reduction, recycling, reuse or detoxification of waste. Most industries utilize some form of waste treatment or disposal. A much smaller number have taken measures to reduce, recycle and/or reuse hazardous wastes generated by them. In the U.S., several industries in the latter group have implemented successful waste minimization or reduction programs which not only reduce hazardous waste going to disposal, but are also profitable.

Waste minimization or reduction may be achieved in one or more of several ways, including:

- source reduction;
- on-site recycling;
- off-site recycling;
- on-site reuse.

Source reduction measures include product reformulation, process change, and raw material substitution. Simple changes such as improved housekeeping measures can be readily introduced to most industries and waste types. Substitution of solvents or corrosive process chemicals is a second method to reduce quantities of hazardous waste. Raw material substitution and housekeeping changes are not capital intensive, and do not require extensive process redesign or down time. On the other hand, source reduction techniques involving product reformulation or extensive process changes will require production disruptions, marketing risks, and often significant capital investment. Consequently, most source reduction programs tend to concentrate on simpler alternatives. Source reduction opportunities are generally identified through an audit procedure, which can be used to rank changes in terms of capital cost, return on investment and overall waste reduction which might be achieved.

On-site recycling is most effective for solvents and heavy metals. Other wastes generally require more complex and intricate recycling facilities. Recycling by the waste generator will reduce the quantities of raw materials purchased in the open market. Disturbances and/or modification of production will be minimized because the recycle process is separate. Recycle is used by drycleaners, metal plating operations, and machine shops, where materials of value can be recovered from the waste streams.

On-site, in-process reuse waste reduction methods are used to recover value from a waste without actually recycling it. For example, wastes with fuel value may be used as alternative fuels, and wastes with high or low pH's may be used as neutralizers. (Although not specifically recycling, these examples illustrate waste reduction by recovery and reuse.) Materials intended for reuse in this way require less treatment than materials intended for recycling. Industries can decrease the volume of waste for disposal while reducing the amount of raw material used to treat the waste. In some cases, such as the mixing of acidic and caustic waste streams, hazardous wastes may be converted to a non-hazardous mixture requiring conventional treatment and/or disposal.

Off-site recycling involves processes and technologies similar to on-site recycling. Off-site recycling operations often depend on multiple sources of waste material providing opportunities for optimizing process equipment and plant size. These operations take advantage of the economies of scale to provide recycling services to small and medium-sized generators who could not recycle or reuse their wastes economically otherwise. Often off-site facilities are dedicated, so that recovered waste is returned to the generator. As with on-site reuse, mixing of hazardous waste may be one way to convert to a non-hazardous mixture. The success of off-site recycling depends on the ability to produce an acceptable material at a lower cost than virgin raw material or disposal.

In Table 3-1 examples of waste reduction techniques applied to various waste streams are summarized. Application of these technologies to specific waste types is presented briefly and the elements which contributed to the success of these programs is highlighted.

Table 3-1

EXAMPLES OF WASTE REDUCTION OPPORTUNITIES

Program Type	Waste Type	Method	Use	Reference(s)
Source reduction (raw material substitution, process change, product reformulation)	Organic solvents (non-halogenated & halogenated)	Substitution of water based compounds for solvent-based	As product coating, as inks	35, p. 1208 49, p. 63 8, p. 87
		Installation of floating tank covers to capture vapours	Included with raw material	49, p. 63 4, p. 12 32, p. 320 32, p. 501
		Use of plastic media blasting instead of solvents	As paint stripper	48, p. 1334
	Phenolics	Installation of * floating tank covers to capture vapours	Included with raw material	32, p. 501
	Oils, emulsions	Source separation of waste streams	Various	4, p. 15
	Heavy metals	Installation of # automated system which generates less waste	As electroplating system	49, p. 63
		Reduction of rinse waters	As final stage in electroplating	50, p. 26 48, p. 1335
	Corrosives	Substitution of mechanical cleaning system for acid cleaning process	To prepare copper sheeting	35, p. 1208
		Substitution of metal beads for caustic solution	To prepare metal surfaces	8, p. 88
		Installation of staged stripping tanks of acid instead of single tank	To clean plating apparatus	50, p. 28

Table 3-1

EXAMPLES OF WASTE REDUCTION OPPORTUNITIES

Program Type	Waste Type	Method	Use	Reference(s)
On-site recycle	Organic solvents (non-halogenated & halogenated)	Distillation, sometimes with decanting	As process chemical	30, p. 31 30, p. 84
		Activated carbon adsorption, followed by desorption and distillation or decanting	As process chemical	23, p. 162 12, p. 249 31, p. 321
		Nitrogen atmosphere in drying ovens, followed by direct solvent condensation	As process chemical	12, p. 249
		Steam stripping, followed by decanting	As process chemical	31, p. 321
	Phenolics	Source separation from aqueous waste stream	As raw material	30, p. 15 32, p. 198
		Ion exchange adsorption, followed by resin regeneration	As raw material	31, p. 340
	Oils, emulsions	Solids settling, followed by hydrocyclone separation	As cutting oil	30, p. 70
		Ultrafiltration	As cutting oil	30, p. 97
	Heavy metals	Electrolytic recovery of metals	As raw material	30, p. 33 30, p. 42
		Ion exchange recovery of metals	As raw material	30, p. 37
		Electrodialysis recovery of metals	As raw material	30, p. 37

Table 3-1

EXAMPLES OF WASTE REDUCTION OPPORTUNITIES

Program Type	Waste Type	Method	Use	Reference(s)
On-site recycle (cont.)	Heavy metals (cont.)	Evaporative metals recovery	As raw material	30, p. 41 30, p. 95
		Reverse osmotic metals recovery	As raw material	6, p. 30
	Corrosives	Air scrubbing of hydrogen chloride gas emissions	As process chemical	32, p. 382
On-site in-process reuse	Organic solvents (Non-halogenated & halogenated)	Incineration of airborne solvent wastes	As fuel for steam generation	30, p. 23
		Separation of solvents used to clean paint manufacturing equipment between runs of different colours	Inclusion in paint of same colour	6, p. 68
	Phenolics	Adsorption of vapours in resin, followed by condensing of mixture	As raw material in the production of adhesives	31, p. 339
	Oils, emulsions	Adsorption by briquettes	As fuel	30, p. 82
		Ultrafiltration, followed by acid concentration	As low grade lubricant	30, p. 94
	Heavy metals	Dust filtration and agglomeration, followed by recycle to furnace	As raw material	23, p. 138

Table 3-1

EXAMPLES OF WASTE REDUCTION OPPORTUNITIES

Program Type	Waste Type	Method	Use	Reference(s)
On-site in-process reuse (cont.)	Corrosives	Separation of acid or caustic waste streams, followed by controlled mixing	As waste stream neutralizer	29, p. 1165 6, p. 34
		Isolation from waste streams	As raw material	32, p. 273
Off-site recycle	Organic solvents (non-halogenated & halogenated)	Distillation by contractor	Returned to industry for use as process chemical	30, p. 30
		Direct sale to other industries	As fuel, or as lower quality solvent +	42
	Oils, emulsions	Solids removal, filtration, and distillation	As components for inclusion in new lubricating oils	6, p. 75 6, p. 76
		Sulphuric acid and clay addition, followed by heating, cooling, and filtration	As re-refined lubricating oils	22, p. 109
		Dewatering and sediment removal	As fuel +	22, p. 109
		Addition of chemical conditioners, followed by hydro-treating on a catalyst bed	As raw material for production of lubricating oils	12, p. 157
		Filtration, evaporation, centrifugation and finally vacuum filtration	As lubricating oil, with residue used as fuel for evaporation stage	22, p. 109

Table 3-1

EXAMPLES OF WASTE REDUCTION OPPORTUNITIES

Program Type	Waste Type	Method	Use	Reference(s)
Off-site recycle (cont.)	Heavy Metals	Separation of metals from waste stream	As scrap metals	30, p. 100 30, p. 102
	Corrosives	Source separation and collection	Sale to other industries as pickling acid, neutralizer, for production of fertilizer, etc.	20, p. 18 32, p. 273
		Incineration, oxidation, and water adsorption	As recycled acid	6, p. 33
		Flash evaporation and hydrolysis	As recycled acid	31, p. 136
		Evaporation and condensation	As recycled acid	31, p. 146

* These techniques reduce waste emissions and are generally referred to as emission controls.

\# The reduction in waste is associated with process changes resulting in less waste than generated historically.

\+ Waste recovery and reuse.

The 3P Program (Pollution Prevention Pays) at the 3M Company is a well-documented and frequently quoted successful approach to waste minimization. This program was initiated in 1974 to reduce the rate of waste generation at the source, using four main approaches to minimize waste as follows:

- product reformulation;
- process modification;
- equipment redesign;
- productive use of waste.

The program was established on the principle that treatment and disposal costs could be reduced if the quantities of waste could be reduced or eliminated. It was also recognized that "end-of-pipe" treatment is costly (both in terms of operating and energy costs), inefficient at times, and subject to maintenance of equipment which does not contribute to profit. Employees from all levels were responsible for identifying methods or procedures to reduce waste. Each suggestion was reviewed and evaluated. Those with the best return on investment (both in terms of capital expenditure and in terms of waste reduction) were implemented first. In the first ten years of the 3P Program, 3M claims to have implemented over one thousand projects with total savings of over $190 million dollars (Auerbach & Boyle, 1984). Measures such as the on-site reclamation of solvents by distillation, and the off-site sale of solvents for use as a fuel have reduced costs associated with solvent disposal. More detailed process changes such as those in a large production line which used to spray solvent-based backing on a material and then cut the product into usable forms has been replaced by a process which cuts the product first, then coats it with a water-based backing. Cutting ends and scrap product may therefore be recycled back into the process and less backing is wasted. Capital costs for this project are estimated to be $5,800,000, with annual savings of $2,380,000.

Some examples of these waste reduction programs are listed below:

- Product Reformulation:
  - Substitution of water-based coatings for solvent-based coatings.
  - Hot melt adhesives substituted for solvent-based adhesives.

- **Process Modifications:**
  - Scrub copper plates with pumice in place of spraying the plates with ammonium persulphate, phosphoric acid, and sulphuric acid. Capital costs were $59,000, annual savings are $15,000 on raw materials and disposal costs.
  - Use of rotating pressure spray to solvent-clean kettles rather than old process of filling kettles with solvent and stirring; spent solvent is reclaimed by sedimentation. Capital costs were $69,000, first year savings on solvents, time and disposal were $61,500.
- Equipment Redesign:
  - Replacement of teflon seals with mechanical seals, resulting in less product contamination. Savings are $332,000 per year.
  - Redesigned a cart used to hold solution, resulting in easier cleaning of cart, use of less cleaning solvent, and less off-spec. solutions. Capital costs were $1,200. Savings are $58,000 per year.
- Productive Use of Waste:
  - Captured dusts and recycled them to the source material. Annual savings are $150,000. Capital investment was $340,000.
  - Removal of ferrous metal ash from incinerator ash for resale as scrap metal. Also reduces the volume of ash for disposal.

Finally, all of the 3M Company plants have access to a computer listing of surplus chemicals available at other facilities. This listing may be consulted to determine if other plants may provide a material before outside sources are contacted.

The success of this program has been attributed to a combination of efforts and ideas, all of which depend on the support of upper-level management. Specific elements of the program which contribute to its success include:

- a company-wide policy which has the support of upper level management;

- awareness of the program at all levels within the company, and inclusion of waste reduction technologies in the development of new processes and products;
- shifting a share of the responsibility for waste reduction to production managers with incentives to reduce waste generation rates;
- a procedure whereby any employees who identify waste reduction opportunities may present their suggestions to management, and are given recognition for successful innovations.

Several difficulties were encountered and overcome as the program became successful. Many were related to the alteration, or the perception of alteration, of product quality. Product quality must be maintained, customer confidence in the product must be maintained, and any regulatory requirements must be met. Reluctance to change successful processes was an impediment to some waste reduction measures. The large process and product changes implemented by 3M required considerable capital expenditure, so that only the most feasible changes with short-term return on investment were implemented initially. Finally, there will always be some residual wastes requiring treatment or disposal.

At DuPont, a committee to coordinate waste reduction measures and to increase awareness of waste reduction opportunities was formed in 1984. The committee concentrated on three factors:

- ensure the availability of organizational and technical resources;
- define target wastes for reduction;
- establish a method for tracking and evaluating the performance of the program.

DuPont had sufficient in-house expertise and resources to initiate and operate the program. Target wastes for reduction had been identified so that a consistency of effort could be maintained throughout the company. To fulfill the third objective, DuPont developed a computer data base to track all company wastes, and monitor their generation. The data base can be used throughout the company to identify available materials, compare the waste-to-

product ratios of similar processes in different plants, and to monitor the change in this ratio with time. Other, more specialized reports may also be prepared.

Waste reduction efforts by DuPont have concentrated on process modifications, recycling, and conversion of the wastes to useful byproducts. Examples of these efforts include:

- modification of nylon production technology to eliminate brine byproduct;
- a polymer/acid solid waste which used to be landfilled or incinerated is now ground and recycled as a raw material;
- succinic and glutaric acids in a complex waste stream formerly used as a fuel is converted to a mixture of esters and sold to paint manufacturers or furniture industries.

Environmental committees have been established in each plant to oversee the implementation of the programs. First-line supervisors are trained to identify opportunities for short-term waste reduction measures.

One reason cited for the success of the DuPont program is the waste reduction committee situated at a level between senior management and plant management. This positioning ensures the involvement of upper management, and enhances the communications between those in a position to approve projects and those responsible for implementing them. In addition, the committee, positioned above plant management, is able to ensure a consistency of effort between plants, and can coordinate the reuse of waste chemicals between plants. Other elements of the DuPont program which contribute to its success include:

- the ability of the waste tracking system to identify target areas for improving waste reduction, and to maintain accurate records;
- the availability of information and the training of staff throughout the company to promote awareness of waste reduction;
- the availability of in-house expertise to develop and implement the waste reduction measures.

Impediments encountered by DuPont are those associated with developing long-term waste reduction measures. Short-term reduction programs utilize quickly installed, low technology measures which generate quick returns. Long-term measures, however, frequently require detailed process analysis, lengthy development periods, down time for installation and testing, and significant capital expenditures.

Allied Corporation has instituted several waste reduction measures. Initial, short-term measures, such as source segregation of wastes, have been used to isolate recyclable or reusable wastes. In one plant, waste calcium chloride formerly discharged to a river is now being collected and further processed for sale as a drilling lubricant. Allied also recycles and regenerates magnesium oxide, used by an electric company to scrub sulphur dioxide from exhaust gases.

An example of a more complex waste recovery process implemented by Allied has been described by Auerbach and Boyle (1982). In this case, an acidic waste stream containing soluble fluorides had been treated with excess lime to a pH > 12. The sludge contained calcium fluoride and excess lime. After generating considerable volumes of this waste, Allied developed a process where the acid waste was mixed with the lime sludge waste producing even more calcium fluoride (or fluorspar). The fluorspar was used in another plant to manufacture hydrofluoric acid. The acid was returned to the original plant for use in the manufacture of uranium hexafluoride.

Allied attributes the success of the waste reduction measures to the following:

- full support of senior management due to an awareness of environmental concerns for waste reduction measures;
- avoidance of disposal costs, including long-term disposal site monitoring and dump closure or clean-up costs;
- reduction in long-term liability for their wastes.

Shell Oil Company of the U.S. uses risk assessment to develop strategies for hazardous waste reduction. According to analyses completed by Shell, there is very little distinction in the cost of hazardous waste management alternatives

when both long-term and short-term disposal costs are considered. The next most significant factor in the analysis was the corporate liability associated with hazardous waste management. An assessment of short-term and long-term risk associated with each option is made in order to select those options which involve the least liability or most acceptable risks. Specific details of the procedures are not available. Shell reported that their program provides a method of successfully reducing their liability and disposal costs for hazardous wastes. A major element contributing to the success of this program is the ability to evaluate all cost and risk (both present and future) associated with each hazardous waste alternative.

The Resource Reutilization Strategies program, developed by Union Carbide, evaluates each waste stream to determine its resource potential. Union Carbide generates many phenolic resin and solvent waste streams which are used as alternative fuels. It is the approach to establishing a company-wide policy, together with specific waste evaluation procedures, which is in part responsible for the success of this program. As it is limited in scope to end-of-pipe applications of waste reduction technologies, this program may encounter difficulties when evaluating wastes without recoverable components or which would be better reduced at their source.

Overall, and accounting for variances due to the different industries, some common elements of established waste reduction programs within companies which contribute to their success include:

- support and incentive provided by policies and action of senior management;
- ability of the programs to reduce costs, and in some cases generate a profit;
- ability of the programs to decrease the long-term risks associated with the liability for hazardous wastes;
- sharing the responsibility for hazardous waste reduction among all levels and operating divisions of the facility;
- consideration of all waste reduction measures, from source reduction to end-of-pipe alternatives;

- establishment of company-wide programs which promote awareness and acceptance of waste reduction measures through training and improved communication, and involve all staff and departments;
- establishment of an information system which records all movements and uses of hazardous materials within a plant or company, and identifies areas of loss or duplication which may be eliminated.

3.2 Waste Exchanges

Waste exchanges currently exist in two different operational categories, passive (or clearing houses) and active (or brokerages). Passive waste exchanges transfer information between a waste generator and a potential end user. Once the initial contact is established, a passive waste exchange will not participate further and does not handle or transport the waste, or negotiate any of the contract terms between the two parties. Active exchanges, however, handle, transport, store, as well as locate and negotiate terms with a buyer.

Passive waste exchanges are usually non-profit organizations, receiving funding from trade associations or governments. In Canada, the Canadian Waste Materials Exchange (CWME) is operated by the Ontario Research Foundation, and exchanges information between companies in all areas of the country. A monthly publication is issued by the organization listing all wastes available from member companies, and all wastes desired as well. From January 1, 1978 to January 1, 1985, a total of 217,000 tonnes was reported to be exchanged through the CWME, 18 percent of which was estimated to be hazardous if the American RCRA definitions were applied. Of the total number of listings in this time period, 15.9 percent were successfully exchanged (Ref. 37). Wastes listed by this and other passive exchanges include liquid or solid wastes with a variety of potential value, ranging from easily marketed materials to unwanted trash. Wastes for which an established market exists, such as solvents, are generally quickly exchanged.

In the United States, passive waste exchanges are regionally operated. A total of thirty-five exchanges existed in the U.S. in 1981; through closure and consolidation, only eighteen of these exchanges were operating in 1984, in

addition to three new exchanges which were established. Of the wastes exchanged through these organizations, only a small percentage would appear to be hazardous wastes that did not have a previously existing market. The California Waste Exchange (CWE) organized the transfer of 16,380 tonnes of waste in 1983, roughly half of which was hazardous, and only 12 percent of which did not have an established market. The total waste transferred by the CWE accounted for only 0.2 percent of the waste generated in California during that year.

Active waste exchanges are privately run, generally for a profit. In Canada, organizations such as oil reclaimers, solvent recyclers, and chemical brokers may be considered active waste exchanges, although this is not usually the case. Waste materials are purchased or collected, and sometimes treated to improve their marketability. Buyers for the recycled materials are found, and the exchange operator makes a profit by increasing the value of the material, or by charging a commission. Active waste exchanges, therefore, only accept wastes which they are confident will be marketable, and often this will not include many types of hazardous waste.

Companies such as Zero Waste Systems of California operate as brokers of chemical wastes from many industries. A staff of chemists and chemical engineers familiar with the industrial uses of chemicals evaluate wastes and try to determine alternative markets for the materials. Brokerage firms of this nature benefit from their knowledge of industrial requirements by being able to find uses for wastes that are often thought of as garbage. Other active waste exchanges often operate only with a few waste types, and within a small number of industries.

A transfer of waste materials will occur between two industries if both derive benefits from the exchange. Generally, this means that there must be savings over disposal costs for the generator, and savings over raw material costs for the consumer. Transportation costs, analysis costs, handling, negotiating, and any legal or permitting costs must also be covered. In addition, liability concerns and any applicable regulatory considerations must be dealt with. Passive waste exchanges are not involved in resolving these issues; active waste

exchanges must resolve them in order to market wastes. These marketing factors account for the majority of the difficulties encountered with the transfer of hazardous wastes through a waste exchange, as described below:

- Passive waste exchanges will list any hazardous waste, but do not actively create new markets for the material. As a consequence, the majority of hazardous wastes transferred through passive exchanges are those with existing markets, such as oils, solvents and acids.
- As industry waste transfer connections become established through passive exchanges, a lack of new markets will decrease the ability of a passive exchange to operate.
- Expansions of passive exchanges to other regions in order to expand the size of the existing market waste transfers is usually limited by transportation costs.
- Active waste exchanges benefit by handling wastes which they may expect to have a large demand for, and which do not require expensive handling and storage costs. Therefore, most active exchanges will avoid handling hazardous wastes. Those that will accept hazardous materials tend to specialize in one particular segment of the existing hazardous waste market.
- Very few active waste exchanges and brokers have the chemical expertise and industrial knowledge required to develop new markets for hazardous wastes.

The role of waste exchanges in the transfer of hazardous wastes would appear to be limited to increasing the use of existing markets. Without the development of new markets for these materials, waste exchanges are not likely to play a significant role in hazardous waste reuse or recycling in the future, either. The potential is there, however, for a larger percentage of hazardous wastes to be transferred than the percentage that currently goes to established markets. Dissemination of information through a passive waste exchange is apparently not enough; only a few active waste exchanges have been successful at developing new markets.

These limitations of waste exchanges are due to a number of factors, largely economic. The profitability of exchange is dependent on both the generator's disposal costs and the consumer's raw material costs. Increases in either cost will increase the feasibility of exchanging. Similarly, alterations to the costs of transportation and handling will affect the viability of an exchange. Secondly, there are informational factors which may limit the amount of material transferred by an exchange. Without knowledge of industrial raw material requirements that could be met by wastes, an exchange will not be able to identify a waste that meets those requirements. Without knowing the total amount of reusable waste material of a particular type that is being generated, an exchange may not be able to perform an economic analysis of the feasibility of exchanging that material. Generally, it is a combination of these factors that results in waste exchanges being limited to assisting in the reuse or recycling of hazardous wastes within existing markets only.

4.0 EXISTING TECHNOLOGY

The major objective of the National Hazardous Waste Action Plan on which this study is based, is the reduction of quantities of hazardous waste requiring treatment or disposal. Based on this objective, we have adopted as broad a definition of recycling as possible so as to include the following:

- direct in-process recovery, recycle and/or reuse;
- waste stream segregation, recovery and recycle on-site;
- waste stream segregation, recovery and recycle off-site;
- waste stream recovery and recycle without segregation (on-site, off-site).

There are additional waste management techniques to reduce the volume of waste requiring treatment and disposal which are not included in the above definition. These are:

- avoid hazardous waste generation by substitution of raw material or process modification;
- product reformulation to remove all sources of hazardous wastes;
- improved housekeeping practices to minimize release of hazardous materials.

4.1 Waste Streams/Existing Technology

Processes and technology to recycle many of the hazardous wastes listed in Table 2-3 have been developed and are available. Successful application of these technologies will depend on several factors including:

- complexity of the waste;
- composition of the waste in terms of individual species, their properties and compatibility of the components;
- concentration of the recoverable components;
- the ease or difficulty to integrate the waste recycling process into the manufacturing process;

- costs and profits associated with the recycling operations.

For example, recovery of solvents from a mixed aqueous waste stream may be complicated by the composition of the waste stream. Typically, the waste separation and recovery may involve solvent evaporation or distillation. Many solvents or solvent combinations form azeotropic mixtures, making it difficult to separate the waste stream components using fractional distillation. Similarly, many metal ions form stable complexes with organic or other liquids. The chemistry required to separate the metallic waste from a mixed waste stream and then recover the metals from the complex may be uneconomical. Thus, although the technology exists to recycle many wastes, each waste stream must be evaluated on a case-by-case basis to determine whether existing technology can be used.

Based on the wastes in Table 2-3 and the generic definitions of hazardous waste adopted in Section 1.0, the relative potential to recycle various waste types is tabulated in Table 4-1. On examination of this Table, there are six waste types with a good potential for recycle. Four waste types have a poor potential for recycle, primarily because of their toxicity, environmental persistence and/or reactivity.

Recovery and recycle of wastes with good potential will be briefly reviewed in terms of the recycle technologies identified above.

4.2 Available Technology for Specific Hazardous Waste Streams

Several of the more successful waste recycling programs are associated with recycling technologies for specific waste streams. In certain cases, the technologies may only be applied to wastes of a similar type produced in a similar process. In other cases, technologies may have a wide spread applicability which is independent of specific processes. Six major waste types are identified in Table 4-1 as having a good potential for recycling. In the following sections, we discuss technologies associated with recovery and recycling of these wastes.

Table 4-1

POTENTIAL FOR RECYCLE OF HAZARDOUS WASTES

WASTE TYPE	RECYCLE POTENTIAL
ORGANIC	
Non-halogenated solvents	Good
Halogenated solvents	Good
Phenolics	Good
Aromatic polycyclics	Poor
PCB's, Dioxins, Dibenzofurons	Poor
Pesticides	Poor
Oils, emulsions	Good
Still bottoms, sludges, residues	*
Other organics	*
INORGANIC	
Heavy metals	Good
Corrosives (non-metallic)	Good
Cyanides	Poor
Sludges, residues	*
Other inorganics	*

* Because of the variety of wastes which may be included in these categories, a case-by-case approach must be followed to determine which waste streams may be recycled. Such an approach is beyond the scope of this report.

4.2.1 Halogenated and Non-Halogenated Solvents

Technologies to recover and recycle halogenated and non-halogenated solvent wastes are similar. Specific technologies selected will depend on several factors, including the nature of the waste stream. The wastes may exist as an essentially organic liquid or as a contaminant of an aqueous waste stream. The degree of contamination of the waste solvent will also affect the method of recovery and the uses made of the solvent. For example, solvents used in the electronic industry will be relatively uncontaminated and can be readily used with minimal re-processing in operations requiring less stringent purity. On the other hand, solvents used in degreasing operations may be heavily contaminated and require extensive processing (filtration, distillation, etc.) before becoming reusable as a solvent.

A major use of recovered or recycled non-halogenated solvents is energy generation. In this case, little or no separation of additional contaminants will take place prior to combustion. Non-halogenated solvents generally have a high energy value, are readily ignited, and can be burned with minimal emissions. The contaminants in the solvents may also be combustible. Pollution control equipment on boilers or other energy devices should be compatible with the recycled solvent. In any incineration process, emission standards must be met to ensure no harmful emissions are released.

Recovery of halogenated solvents either for direct recycle to the process where they originated or to related solvent usages is common. Use of halogenated solvents for energy recovery is possible, but does not occur as frequently as with non-halogenated solvents. There are some restrictions on the use of halogenated solvents for energy, including the need to scrub toxic and corrosive contaminants from the exhaust gases. In addition, energy recovery values from halogenated solvents are lower than from other solvents. These factors make recovery and recycle of halogenated solvents more attractive than energy recovery.

Solvents may be recovered for both on-site and off-site recycling or energy recovery. Process technologies and equipment have been developed for the

recovery and recycle of solvents. The equipment is available for small operations and batch processes. With this equipment, in-process recovery of solvents may become economically preferable to other waste management options. Suitably sized equipment may also allow off-site recovery of solvents of several types simply by batch processing in the same equipment. For example, a single fractionation column could be used to recover both halogenated and non-halogenated solvents which boil in a similar range.

The most common methods used for solvent recovery include the following:

- Adsorption of the solvent on carbon, followed by desorption with steam, condensation and separation from the aqueous phase. This process is well suited for water immiscible solvents and processes using a single solvent. Two units are required for continuous operation and it may be necessary to control the generation of corrosive materials when halogenated solvents are being recovered.
- Fractional distillation is a common method to separate and recover solvents. This method is suited to solvent mixtures provided the boiling points are well separated. Efficiency of separation and removal of solvents using this method tend to be very high.
- Scrubbing of solvents is another common method to recover solvent wastes. Once scrubbed or extracted from the mixture, the solvent must then be recovered by distillation or equivalent process. Removal efficiencies tend to be low with this method.
- Additional methods for solvent recovery include air stripping, solvent extraction and resin adsorption.

4.2.2 Oils and Emulsions

This category of hazardous waste includes crank case oils, lubricants, greases, cutting oil emulsions and other oily wastes. Uses made of these products, and therefore the quality and characteristics of these oils, are quite varied, requiring many different methods and processes to recover the materials for reuse. Higher quality waste oils may be re-refined and resold as lubricants. These oils may be mixed with virgin oils prior to resale or sold without

blending. Alternatively, the oils may be recovered and resold to industries for the same use as their original applications. Emulsions and waste oils other than lubricants have also been recycled. If not re-refined, a major use of waste oils and lubricants is for energy production. The quality of waste oils may be suitable for use in industrial boilers with minimal treatment. Reclaimed oil has also been used for road oiling in some jurisdictions. However, it is being increasingly recognized that road oiling is not a satisfactory method of disposal of these wastes. Consequently, in many jurisdictions these practices are no longer permitted.

Methods to reclaim and re-refine waste lubricants and oils rely on similar techniques to remove contaminants such as metals, water and other suspended materials. The waste oils are often first treated with sulphuric acid followed by filtration through clay to remove solids and moisture. At this point, there is a divergence of process. In some methods, the oils are filtered a second time and then blended with virgin oils and additives prior to resale as a lubricant. In other methods, the oils are fractionally distilled and then blended to produce lubricants of the desired quality. In certain instances, the oils may be hydro-treated to remove sites of unsaturation. Most processes generate quantities of oily contaminated acid sludge which will require further treatment and separation prior to disposal.

4.2.3 Corrosives

The major hazardous waste generated in Canada and United States are corrosive wastes, see Table 2-2 (Noll, 1986). Of the corrosive wastes, sulphuric acid is the largest single waste stream in the U.S. (California Department of Health Services, 1986). Although technologies have been developed for recycling of sulphuric acid and other corrosives, these technologies are not widely used. Corrosive wastes tend to be complex and difficult to treat. It is often less expensive to use alternate disposal or treatment options. In addition, costs of recovery and recycle may exceed original production costs.

For these reasons, recycling of caustics and acids is frequently limited to reuse of spent caustics and acids in applications other than those from which they

were derived. As indicated above, these products are inexpensive to manufacture and large quantities are produced annually. Corrosive waste streams are often contaminated with metals and other materials which make recycling of these wastes very difficult. Corrosive wastes are often not sufficiently concentrated for recovery and recycle. Consequently, although technologies exist for recycle of many corrosive wastes, the major use of these materials is for neutralization or direct reuse in the manufacture of products such as fertilizers and pickling acids.

4.2.4 Heavy Metals

Heavy metal wastes are generated by both the primary and metal fabrication industries. Waste streams include metal plating wastes, pickling wastes and smelter waste streams, among others. The characteristics of the waste streams depend on the process from which they were derived, which in turn determines the technologies which can be applied in the recycle of these wastes. In most cases, heavy metals are recycled to the process from which they were generated. Consequently, most existing metal recovery operations are on-site, with virtually no off-site recycling (California Department of Health Services, 1986).

The specific nature of the technologies required to recycle metallic wastes may be a factor in the shortage of off-site treatment facilities. Many of the waste treatment and recovery processes are specifically designed for particular waste streams. For this reason, it may be difficult to establish off-site recycling operations which are able to treat a range of heavy metal waste streams. Viable treatment and recovery options for metal plating wastes include electrolysis, electrodialysis, evaporation and ion exchange. These technologies have been used as separate stand-alone technologies or as components of a more complex waste treatment system. Precipitation, filtration and magnetic separation of metals have been used on other wastes. All of these technologies are capable of concentrating the metals in a waste stream, but most are also very waste specific. For example, because many metallic waste streams are acidic, ion exchange resins are not suitable for separation of metals from the waste stream. Other metal wastes are poorly reclaimed by electrolysis or are expensive to reclaim by evaporation.

4.2.5 Phenols

Phenols and phenolic wastes are removed from waste streams as a pollution control measure. Improved housekeeping practices have reduced the quantities of phenols reaching waste streams, thereby reducing quantities of phenol for disposal. Recovery and recycle of phenols from waste streams occurs infrequently. Recycling operations appear to be restricted primarily to on-site operations. Off-site recycling of phenolic wastes is not common, most likely because of the limited volumes of phenolic waste generated and their high water solubility. The waste streams containing phenols are often very complex and difficult to treat.

Methods which have been applied to recovery and recycle of phenolic wastes include:

- solvent extraction;
- evaporative concentration;
- ion exchange;
- adsorption, followed by regeneration by an organic solvent.

In most cases, the phenolic waste is recycled as raw material.

4.3 Technology for In-Plant (In-Process) Recycling

Opportunities for hazardous waste reduction and recycling within a plant or manufacturing facility can be categorized as follows:

- in-process recycling;
- plant housekeeping and operating practices;
- process technology and/or equipment modifications;
- raw material or process solvent substitutions;
- segregation of waste streams;
- end product reformulation.

Examples of each of these techniques for waste reduction have been presented in Section 3.0 above.

Clearly, some of these changes will be more readily implemented than others. For example, "end-of-pipe" waste reduction changes are easy to implement, consist of add-on equipment and present little risk, either to process, product or achievable results. These add-on changes fall into the categories of end-process recycling and plant operations. In contrast, modification of process technology and/or equipment is often more difficult and risky to implement. Changing process is risky for several reasons. The product quality may suffer, particularly during start up and commissioning. Even this temporary fluctuation in product quality could be costly in terms of retaining market share and market advantage. The risk factor will depend on the type of production process, the frequency of reformulation of product, the competition for a particular market niche, etc. Process change often requires redesign of process equipment and operating procedures. Careful assessment of these changes, coupled with extensive testing, may be required before process change can be considered by management. Such changes must also offer a high return on investment, as will be discussed in Section 6.0. However, the potential payoff may be large in the form of increased efficiencies and reduced operating costs. These changes provide good opportunities for front-end waste reduction and are applicable to a wide range of industries. Replacement or substitution of process raw materials is also often more difficult than making "end-of-pipe" changes. Examples of this type of change include replacement of solvent or substrate with non-hazardous waste generating materials. Such changes may have significant negative effects on operating efficiencies, costs and product quality. They may also require extensive research and development in order to implement. As with the process/technology changes, there is a potential for substantial reduction in cost due to savings on solvent purchases if replaced by water, and reduced hazardous waste management costs. Finally, the riskiest and least implemented change for hazardous waste reduction is product reformulation. The major risk associated with this option is the loss of market confidence. Customers often are very skeptical concerning product quality and performance following reformulation. There is a very definite risk of losing customers both in the short term and long term. In addition, there will be

substantial costs associated with re-educating customers and re-establishing confidence in the reformulated product.

Industry in the U.S. has reported making changes under each of the above categories to reduce hazardous waste. These changes have been implemented across a wide range of industry sectors as can be seen from the data in Table 4-2. It is clear that the method used most frequently to reduce hazardous waste is in-process recycling. This option has also been implemented across a very large number of industrial sectors. The second most frequently implemented method to reduce hazardous waste is the modification of process technology and equipment. This type of change has been implemented across a broad spectrum of industrial sectors as well.

The foregoing discussion has suggested a number of technological constraints or barriers to recycling which will dictate which options are available to a particular industry and a particular waste stream. For one reason or another, certain options identified in Table 4-3 will not be available to some industrial sectors. Still other options may be restricted by the process design and operations at specific plants or by limited information and/or technology which may be available. For example, several industries operate with a well-established, proven process based on high-volume production. These products are often stable and there is little call for product or process change. In these industries, the opportunity for hazardous waste reduction by process or equipment modification is usually small.

The high volume production and mature process used by some industry sectors, such as pulp and paper, petroleum refining, etc., will provide little opportunity to reduce hazardous waste generation by process modification. In-process changes may also be restricted by product quality. In cases where product quality is of utmost importance, such as pharmaceuticals or fine chemicals, there is little or no opportunity for in-process recycling of hazardous materials. **Industries which manufacture products to exacting standards have little or no opportunity to recycle or reuse waste materials internally.** Several factors restrict internal recycling of waste materials even though they may be of high

Table 4-2

WASTE REDUCTION METHODS*

SIC	Industry	Waste Reduction Methods: In-Process Recycling	Plant Operations	Process Technology and Equipment	Raw Mater. Substit.	End Products	Waste Management	Totals
10	Metal mining	-	-	-	-	-	1	1
14	Nonmetallic mining except fuel	1	-	-	-	-	-	1
16	Heavy construction	-	-	-	1	-	-	1
20	Food and food processing	6	-	2	-	-	5	13
22	Textile mill products	6	-	4	1	-	1	12
24	Lumber and wood products	5	-	-	-	-	-	5
26	Paper and allied products	5	1	4	2	-	1	13
27	Printing and publishing	3	-	-	1	-	1	5
28	Chemicals and allied products	30	16	37	6	2	14	105
29	Petroleum and coal products	3	-	1	-	-	1	5
31	Leather and leather products	3	-	3	1	-	-	7
32	Stone, clay, and glass products	4	-	8	-	-	-	12
33	Primary metal industries	12	-	11	-	-	7	30
34	Fabricated metal products	23	7	14	5	1	8	58
35	Machinery except electrical	1	3	4	-	-	4	12
36	Electrical and electronic equipment	4	-	2	1	-	2	9
37	Transportation equipment	1	-	5	1	-	-	7
38	Instruments and related products	1	2	-	-	-	1	4
39	Miscellaneous manufacturing industries	2	-	-	-	-	-	2
49	Electric, gas, and sanitary services	-	1	-	-	-	10	11
76	Miscellaneous repair services	-	-	1	-	-	-	1
Totals		110	30	96	19	3	56	314

* Source: Office of Technology Assessment, 1986.

value. As indicated previously, products manufactured to high purity standards may be rejected when quality is substandard. In addition, customers may not accept a high quality product manufactured with recycled material, even though it may meet all specifications. Finally, the high quality products (pharmaceutical, fine chemicals, electronic components) have a high profit margin and therefore very little incentive to use recycled materials. The quality of the waste stream may be sufficiently high that there are opportunities for direct reuse of the waste by an industry sector with less exacting standards.On the other hand, industries which frequently change product design may have more opportunity and options available to reduce hazardous waste. However, product redesign does not necessarily mean that there will be opportunities for reduction of hazardous waste by process modification. Table 4-3 illustrates the most commonly available options to a range of industries.

Hazardous waste reduction may also be constrained by a barrier to exchange of information and technology between competing companies, particularly for process modifications. Companies which perceive that process changes designed to reduce hazardous waste management costs and which will give them an advantage in a competitive market may be reticent to share the technology. There is a tendency to restrict the availability and limit transfer of technology from company to company where there is a perceived market advantage associated with a new process. Industries with a high production volume and mature stable process tend to share information on process changes. However, many processes remain proprietary or not available, particularly those involving chemical conversions. The equipment configuration and design for each plant differ from plant to plant, requiring site-specific design changes and testing for many in-process changes, even when the technology is readily available. Hazardous waste reduction technology is more widely developed in some industry sectors than in others. In those where waste reduction technology has been developed, the constraints are not as severe as in those where processes are proprietary or protected.

Table 4-3

POTENTIAL FOR WASTE REDUCTION OPPORTUNITIES ACROSS DIFFERENT INDUSTRY TYPES

Company/ Industrial Characteristic	Example Industries	Operations Changes	In-Process Recycling	Process Changes	Input Substitution	End Product Changes
Mature process technology, high volume product	Rubber Petroleum Commodity chemicals Paper products Lumber	+	+	-	-	-
Very stringent product specifications or high product quality demands for high cost/high profit products	Pharmaceuticals Weapons Robotics Specialty chemicals	+	-	-	-	-
Frequently changing, high-tech products for industrial use	Electronic components Medical equipment	+	+	+	+	-
Job shop processing of many different industrial products	Electroplating Printing	+	+	+	+	-
	Foundries Machine shops	+	+	-	+	-
Changing production technology for commodity goods	Steelmaking Nonferrous metals Textiles	+	+	+	-	-
Large-scale manufacture of consumer goods	Automobiles Appliances Consumer electronics Paints	+	+	+	+	+

Source: Office of Technology Assessment, 1986, p. 95.

The availability of information and/or technology may also be restricted by process design and/or industry size. Process designs have similarities from plant to plant, but often have several specific transformations or conversions which are constrained by raw material source, product mix desired, etc. These variations in process are often sufficient to prevent a direct transfer of technology from one plant to another. Only the least complex of process changes will be implemented by a direct technology transfer. Since many of the process changes will require a certain amount of research and re-design to fine-tune the technology, smaller companies may not have the financial ability and technical manpower to carry out the necessary research and development. In addition, development of opportunities for hazardous waste reduction by process modification may be severely restricted by these constraints.

Yet another constraint in process redesign for hazardous waste reduction is the risk associated with such changes. In most industries, there is a tendency to look for a proven technology and/or piece of equipment so as to minimize or reduce any risks associated with process redesign.

Small companies tend to purchase raw materials and technology from larger companies. Consequently, **opportunities for small companies to reduce hazardous wastes by process changes are often dependent on the supplier to develop such changes.** The technology used by smaller companies often is designed to operate with raw materials from a specific supplier. Until the supplier develops a process or raw material which reduces the hazardous waste generation rate, the smaller companies will be constrained to rates higher than necessary.

Finally, in the past it has been difficult for small firms to obtain information on the contents of raw materials provided by larger suppliers. **Often chemicals or raw materials are supplied with little or no information, due to the proprietary nature of these materials.** Under these conditions, it may be difficult or impossible to select materials to minimize hazardous waste generation. As the Workplace Hazardous Materials Information legislation begins to take effect, this barrier will become less important.

Waste streams are often combined throughout the manufacturing process with the result that many non-hazardous wastes are mixed with hazardous wastes. Two barriers to the reduction and/or recycle of hazardous waste arises as a result of this practice. **The waste stream may become too complex to economically separate the hazardous components for recovery. The concentration of the hazardous components may be reduced below the level for recovery.** Mixing of hazardous and non-hazardous waste streams will become less common as it becomes more costly to handle hazardous waste. These barriers may become less significant at that time.

4.4 Technology of Off-Site Recycling of Hazardous Waste

Recycling of hazardous waste off-site is based on "end-of-pipe" technologies. As a result, many of the processes have been developed and equipment and technologies are available for implementation. Most processes can be adapted to different volumes of wastes or can be run as batch processes. Off-site recycling of several hazardous wastes has been in operation in Canada for several years. The most commonly recycled wastes are non-halogenated organic solvents and waste oils.

There are several technological constraints for off-site recycling operations. These constraints include:

- waste stream composition;
- the volume of available waste;
- the market for recycled materials.

Each of these major constraints will be discussed below.

Perhaps the most severe constraint on off-site recycling of hazardous waste is waste stream composition. It is common practice for industry to mix all waste streams resulting in a complex mixture of materials for recycling. These complex mixtures have adverse effects on the recyclability, including the following:

- decreased value of recycled materials due to subsequently reduced product quality;
- increased difficulty in separation of the mixtures;
- increased number of steps required to recycle the hazardous waste;
- increased storage requirements for intermediate steps in the recycle process;
- limited volumes of hazardous wastes, which requires processing of small batches or limited continuous operations.

These adverse effects will have a greater or lesser influence on the recyclability of a hazardous waste depending on its ultimate end use. For example, recycling of non-halogenated solvents and waste oils for energy value will not be as severely constrained by these effects as would be the recovery of these solvents and lubricants for reuse in the original processes. Conversely, although processing of less complex waste streams is more straightforward, there are several inherent barriers to recycling less complex streams. These include the following:

- restricted volumes for processing;
- the necessity for primary industry to separate and isolate several waste streams; (It may be more economical for the primary industry to recycle directly, once waste streams have been separated.)
- higher transportation costs associated with more frequent collection and/or handling of hazardous waste materials.

The volume of hazardous waste available for recycling places constraints on the viability of off-site recycling. This depends on a number of complex factors related to the operation of the primary industry, such as cost for disposal of hazardous waste, in-plant recycle opportunities, government regulations and various incentive programs. Waste management decisions by industry are influenced by economic factors. Consequently, the current low cost for hazardous waste land disposal or an improved return on investment for in-process or in-plant recycling will tend to reduce the volume of hazardous waste available for off-site recycling. Thus, the viability of the off-site recycling industry will be constrained by and depend on the following:

- increased capital and operating costs per unit recycled for small volume hazardous waste streams;
- availability of process equipment of suitable size and configuration for processing small volumes of hazardous waste; (Note that all off-site recycling processes are "end-of-pipe" and equipment may be more readily available in a variety of capacities than for in-process equipment. The significance of this constraint may vary from case to case.)
- restricted availability of hazardous waste with the specified composition.

It is possible that the constraints placed on hazardous waste recycling by product composition and waste volume may require more careful siting of off-site recycle facilities. For example, the viability of a recycling operation will depend on a ready supply of wastes for recycle and a ready market for the recovered products. The high cost of transportation dictates that recycling operations should be located close to both supplies and markets. Conceivably, siting off-site recycling facilities to process hazardous waste from a specific group of inter-related industries (where wastes from one industry can be re-used by a neighbouring industry) will be necessary to establish viable operations.

Finally, **a major constraint on off-site recycle of hazardous waste is the market area**. The market area may be restricted by a number of factors, including the following:

- geographic constraints for economic waste collection and recycling may severely restrict available area;
- the market area may be increased by improved quality and/or quantity of recycled hazardous waste;
- transportation costs are often the major disadvantage to recycling of hazardous waste; (The quantity of materials may be too small or the distance too great for economic transportation.)
- the geographic area for hazardous waste generators supplying a recycle facility are similarly influenced.

Both on-site and off-site recycling of specific hazardous waste streams can be affected by the technological factors discussed above.

4.5 Specificity of Technologies

The highly specialized nature of recycling technologies acts as a disincentive to installing off-site facilities for recycling of hazardous wastes. With the exception of organic solvents, there are no "package" technologies which can be simply and quickly installed to recycle a particular waste type. Recycling technologies have often been developed by one company to suit their needs and their specific waste stream, and are not easily adapted to another waste stream.

Depending on the processes from which the waste originated, the composition and concentration of the waste, and the intended use of the recovered material, several technologies may be appropriate for recovery and/or recycling of one or more components. It may be necessary to characterize the waste stream involving extensive analytical testing on the wastes prior to identification and evaluation of technologies suited to recovery and recycle. Pilot tests may be required to "prove" the technology, and modifications to meet specific quality standards will be determined on a case-by-case basis. Essentially, most recycling technologies must be designed specifically for a particular waste stream.

5.0 ECONOMIC BARRIERS TO RECYCLING

5.1 Identification of the Economic Barriers in Canada

Waste recycling processes and equipment changes are often sound economic investments for industrial sectors. Waste reduction and recycling investment documented in the literature (Adamson,1984, Campbell, 1982, Taylor,1982) is reported to provide favourable returns on relatively small amounts of capital. While such opportunities may not be available to companies at all times, a large amount of waste reduction and recycling is possible and has been undertaken by companies without excessive amounts of capital and with relatively high returns on investment. This is currently true, when firms are in the early stages of waste recycling and reduction. However, as interest in or pressure for waste reduction or recycling increases, a company will exhaust the obvious, simple, inexpensive and quickly implemented ways of achieving this goal. The amounts of capital which then must be invested to achieve further waste reduction or recycling may increase, while certainty about the return on those investments is likely to decrease. Additional waste recycling and reduction efforts may then require changing the fundamentals of processes and products in new and untried ways. These more complex measures may depend on intimate knowledge of specific and unique details of the company's technology, operations and products. Companies usually cannot rely on outside information and the experience of others, but must take the risks of research and implementation themselves.

For most generators of waste, a combination of greater investment requirements and greater uncertainty about payback become barriers to recycling and waste reduction at some point. Determining when this point has been reached may be a matter of management perception and opinion, as some firms, especially small ones, even have problems of implementing basic production technology advances. In such cases, lack of attention to waste recycling or waste reduction may be a symptom of a larger management problem.

Older, troubled manufacturing industries may encounter the investment uncertainty barrier early on. For many smaller generators, with few technical resources and with difficulties in raising capital, this barrier may be virtually

insurmountable. To overcome the investment uncertainty barrier and pursue the most effective means of waste recycling or waste reduction, industry may need strong motivation, either from within (e.g. greater managerial support) or from outside (e.g. direct government assistance). Many firms have not yet had enough time to implement fully, even the easiest forms of waste recycling or reduction, much less to consider or examine more costly approaches. Provincial and Federal government policies and programs have not paid much attention to waste recycling or waste reduction. Information and technology transfer are in early stages and many industries are only beginning to undertake waste recycling or reduction as an end to itself.

There are a number of other reasons why many more businesses are not recycling their wastes. One major barrier that may confuse potential savings through pollution prevention expenditures is the discrepancy between capital and operating costs. Waste recovery and waste disposal differ in their relationship between capital costs and operating costs. Industries that make on-site waste recovery investments usually incur a relatively large capital expenditure, while operating costs can be relatively low, aided by the value of the recovered materials that help pay for the cost of recovery and offset the capital cost. Firms that dispose of wastes off-site, however, will have low capital expenditures, and high operating costs. Operating costs are likely to increase on a year-to-year basis as the cost and restrictions of off-site disposal increases. The high capital costs for waste recovery is a barrier to recycling, especially to smaller industries.

Once attractive waste recycling opportunities have been identified, they still must be demonstrated as preferable to pollution control. In most companies, pollution control is the known, conservative option that provides a clear result for an investment and creates little disruption or risk to current production. For many firms, waste recycling is a novel approach to waste management that has the potential for widespread effects including interference in both process operations and product quality. Tracing every waste back through the process can be an overwhelming task. Since they have limited resources, many companies feel that they do not need to identify waste recycling opportunities.

Recycling may, therefore, be perceived as economically risky by industry officials.

Current Cost of Treatment, Transportation and Disposal: The cost of landfilling of wastes is probably one of the strongest disincentives to recycling. It is felt that the cost of landfills does not reflect true, long-term costs of the disposal of these wastes. Historically, land disposal has been the easiest and cheapest waste management technique. Currently in many municipalities, cost of landfilling is being subsidized by local governments. Inexpensive landfilling is financially attractive to many firms, and as long as this remains so, industry will continue to invest in this disposal method rather than recycling their wastes.

There are two major issues (Adamson, 1984) associated with transportation: preferential rates and distance. In any transportation issue, normally the economic gain in transporting the hazardous waste must outweigh their (local) disposal costs. Also, the user's cost must be less than raw materials cost. Unless there are unusual circumstances, typically wastes are not transported more than approximately 50 miles at a profit, Table 5-1. Before any waste can be transported, the technical, economic, marketing, and legal issues must be resolved to all parties' satisfaction.

Although the requirements are many, a mismatch of one variable can prevent a transfer from taking place. Table 5-2 shows the requirements grouped into a logical sequence.

Canada offers uniquely difficult features for the development of a national transportation system. From a transportation point of view, the topography of the country along with a considerable economic regionalization accentuates the four thousand mile stretch of the nation. Regional economic specialization lends itself to considerable inter-regional trade, while topography provides difficult conditions for long-haul transport.

Transport pricing in Canada is probably more complex than that of any industry. In the movement of commodities, the character of transport price

Table 6-1

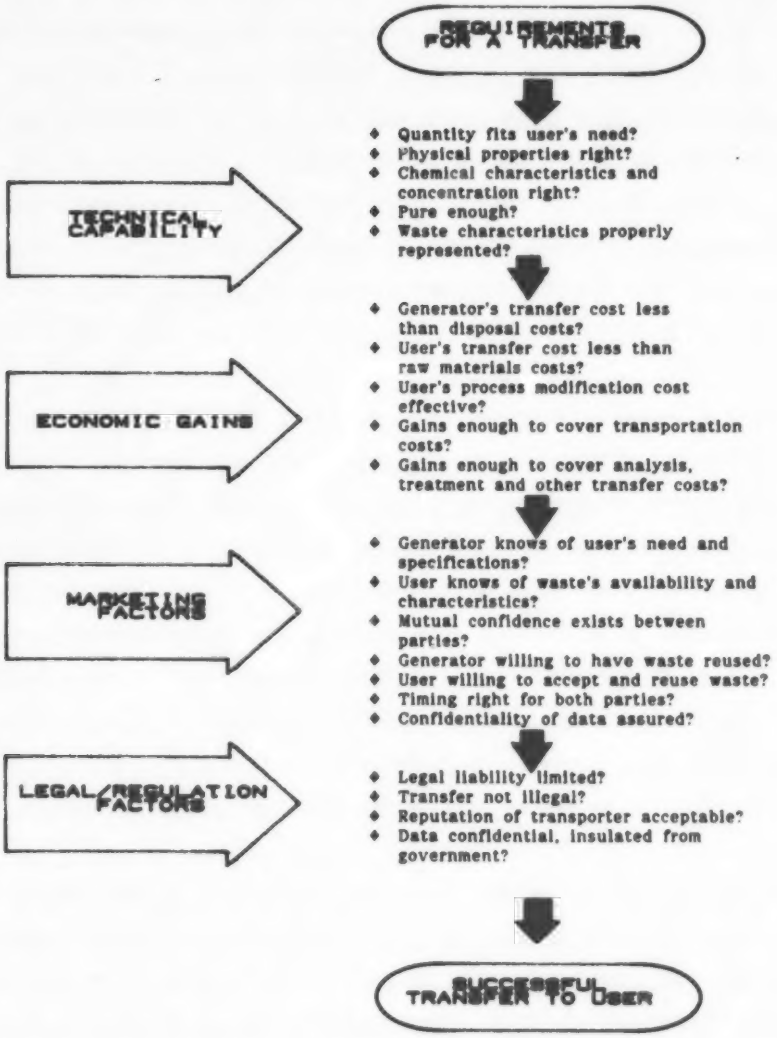
ANALYSIS OF DISTANCE TRAVELLED BY WASTES

DISTANCE	NUMBER SHIPMENTS	PERCENT OF COMPANIES REPORTING
‹ 50 miles	129	35.4
50 - 100 miles	36	9.9
100 - 200 miles	34	9.3
20 - 500 miles	136	37.4
500 - 1000 miles	13	3.6
›1000 miles	16	4.4
Did not state	82	
Total	446	100

Source: Process Industries Canada, Vol. 69 No. 2, April/May, 1985

Table 5-2

REQUIREMENTS FOR A TRANSFER


REQUIREMENTS FOR A TRANSFER
TECHNICAL CAPABILITY
◆ Quantity fits user's need?
◆ Physical properties right?
◆ Chemical characteristics and concentration right?
◆ Pure enough?
◆ Waste characteristics properly represented?
ECONOMIC GAINS
◆ Generator's transfer cost less than disposal costs?
◆ User's transfer cost less than raw materials costs?
◆ User's process modification cost effective?
◆ Gains enough to cover transportation costs?
◆ Gains enough to cover analysis, treatment and other transfer costs?
MARKETING FACTORS
◆ Generator knows of user's need and specifications?
◆ User knows of waste's availability and characteristics?
◆ Mutual confidence exists between parties?
◆ Generator willing to have waste reused?
◆ User willing to accept and reuse waste?
◆ Timing right for both parties?
◆ Confidentiality of data assured?
LEGAL/REGULATION FACTORS
◆ Legal liability limited?
◆ Transfer not illegal?
◆ Reputation of transporter acceptable?
◆ Data confidential, insulated from government?
SUCCESSFUL TRANSFER TO USER

Source: Hazardous Waste Consultant, May/June, 1984

structure varies from area to area, from commodity to commodity, and for varying lengths of haul.

The rate classification system allows rates to vary from a low of as little as one-half cent up to as much as ten cents per tonne mile, and bears little relation to the cost of performing the service. Discriminatory pricing, as it is called by the economists, has not been imposed on society arbitrarily by the transporters. The traditional principle of rate-making represents a form of cross subsidization. Raising the rates for some traffic beyond relevant attributable costs imposes an expense burden on that traffic. This is done in the interest of satisfying the overall financial need of the transporter in a manner conducive to the efficient provision of transport in the long run.

Differential transportation rates therefore do act as a barrier to the pricing structure of hazardous waste movement or the movement of recycled products. The current pricing structure charges more heavily for small shipments moving short distances, and less heavily for large shipments moving over longer distances. High volume, long-haul users, namely those in the raw materials production industry, are able to negotiate "preferential rates" with the carriers based on large, long-term quantities and long-haul distances. Discriminatory rates therefore do exist, affecting all low-volume items, not only recycled products or wastes. There is a need for some equalization of transportation rates to make them competitive to those of the primary products industry.

Cost of Virgin Materials: It is commonly felt that the price of raw resources may not reflect their true value. This price, compared to equivalent costs to recycle hazardous waste, discourages recycling technology. The cost of virgin materials does not always reflect their growing scarcity because of government initiatives that have stimulated the intensive use and low prices of raw materials in Canada. If the true costs were added to the raw resources, it would probably add to the competitive position of recycled wastes.

Lack of Volume Markets: Large generators frequently have the resources to market their more "profitable" wastes. Small quantity generators with small amounts, or with unique wastes, may find it extremely difficult to place

quantities of specialty wastes in the market. One of the most difficult problems faced by waste generators is the desirability to notify potential users in a large geographical area of a waste to be recycled. Yet from an economic standpoint, transportation costs and distances are a major barrier to recycling of wastes. (Table 5-3)

Lack of Adequate Incentives such as Tax Breaks, Subsidies, Low Interest Bonds, and Favourable Fee Structures: Governments in Canada can encourage the social goals such as recycling of hazardous waste through incentives. There is widespread belief that the current policies could be technically, socially and economically more effective.

Assistance and incentives can take the following forms:

- direct subsidies, grants, interest-free loans;
- indirect subsidies such as taxation policies, or programs funded largely by government finances, or disincentives by taxation or certain activities;
- scheduled pricing disparities.

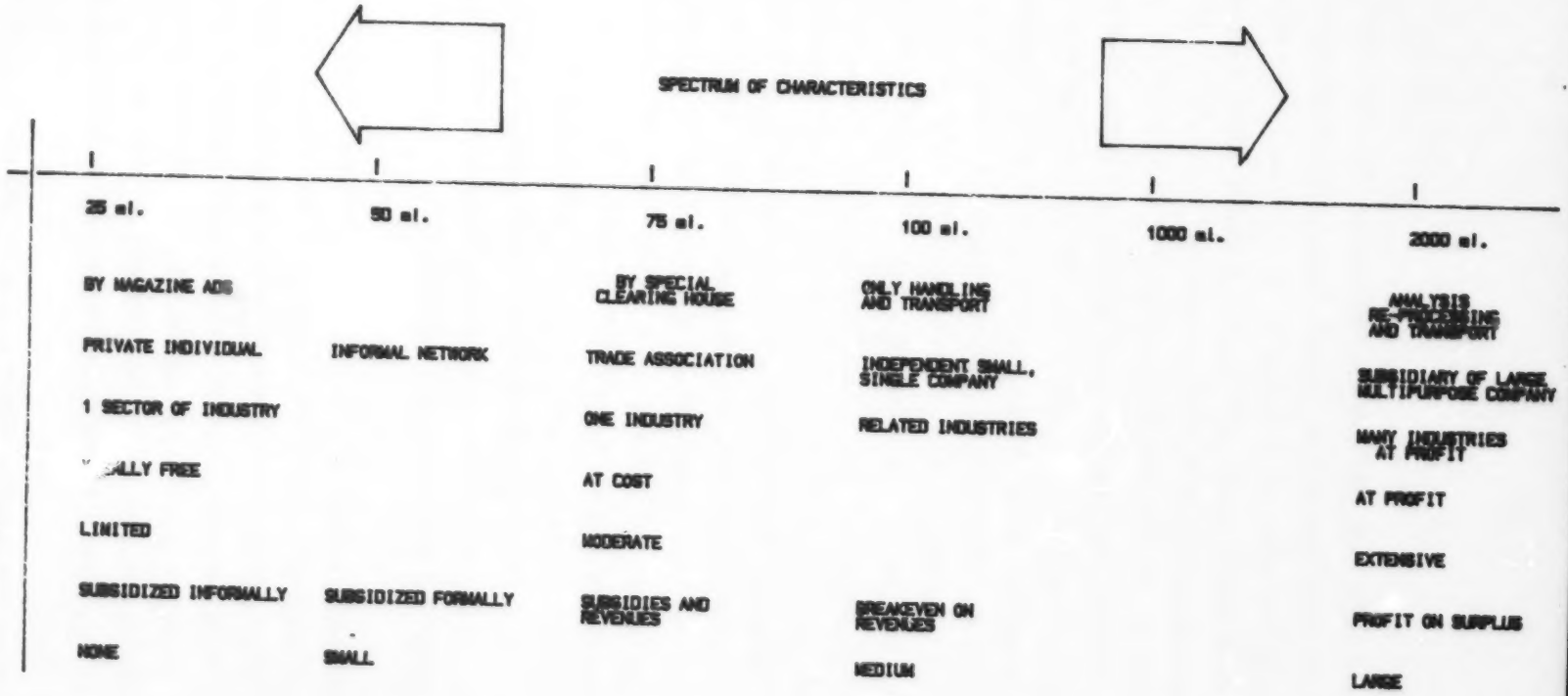
Although market conditions may not motivate industries to recycle their waste, specific financial encouragement can assist companies in pursuing recycling options that would not normally seem economical.

Cost of Implementing Recycling Practices: The capital cost of introduction of recycling technology acts as a discouragement to industries. Many company officials have the assumption that waste recycling or waste reduction will entail large capital expenditures. Hastily dismissing recycling without sufficient investigation might eliminate the opportunity to increase profit margins. The capital cost of investing in waste reduction may initially be high, however in many cases the investment is not only sound, but economically lucrative.

Risk of Investment/Uncertainty of Payback: Greater investment requirements and uncertainty about payback may deter investment in recycling, especially in smaller firms.

TABLE 5 - 3

CHARACTERISTICS INFLUENCING TRANSFER OF WASTE



Source: Waste Clearinghouses and Exchanges
Arthur D. Little Inc., Cambridge Mass., October, 1976

5.1.1 U.S. Office of Technology Assessment Industry Survey

The U.S. Office of Technology Assessment conducted a survey of industry personnel in February and March, 1986, on hazardous waste reduction. The survey was divided into three parts:

Part 1 determined information about the type, size and location of the company;
Part 2 dealt with the current waste reduction efforts of the company; and
Part 3 asked for the views on future waste reduction efforts, both by industry and by government.

The results were as follows:

A. Two most important factors in waste management:

- the rising costs of waste management;
- increasing difficulties in using land disposal.

The scarcity of technical information about waste reduction and the failure of top management to make reduction a high priority were rated least important.

B. Obstacles to waste reduction efforts:

- economic factor - the dollar value of benefits from waste reduction and the costs of carrying it out were rated the most significant barriers by all respondents. However, small businesses were almost twice as likely as large companies to cite other barriers, such as the nature of waste streams, and the costs of managing specific wastes.

C. Among the waste reduction activities implemented:

- in-process recycling was ranked first, particularly by large companies;
- changes in equipment technology was ranked second;
- improvements in housekeeping and general operations changes were ranked third.

The least-used action of all companies was in making changes to their final product.

D. Programs which would be felt to have the greatest positive impact on waste reductions were:

- a tax credit for capital spending;
- reduced possibilities for land disposal through enforcement of regulatory programs;
- increasing technical information and assistance programs of all kinds.

Programs that were rated as having little or no significant impact were:

- awards for outstanding waste reduction efforts;
- Federal grants for State waste reduction programs;
- a mandated Federal waste reduction schedule;
- regular reporting by industry on toxic chemical generation.

5.2 Establish Recycle Opportunity Cost

For recycling to be attractive, a firm must make an investment in either equipment or technology. To minimize costs a firm will set the marginal cost increase for recycling investment equal to the alternatives, usually disposal costs. Examples of alternate disposal costs are shown below.

As legislation is mandated to enact minimum standards of safe waste disposal practices, alternate disposal technologies become more sophisticated and more costly, making recycling more attractive. (See Table 5-3)

Investment alternatives can be compared in a number of different ways. present worth and annual worth are two commonly used approaches. Another is the payback period. Payback periods of three to four years are common within the process industries and payout periods of over four years are generally foregone. Because of the high perception of uncertainty in recycling projects, payback times of less than three years are often required. High levels of

uncertainty may cause management only to approve projects with even shorter payback periods. Investments in new equipment and processes usually take three to five years to perfect, and essential new waste recycling projects are turned down. The management structure often discourages risk taking, and thus holds back the adoption of new technologies.

Table 5-4

COST OF DISPOSAL OPTIONS

	Price Can. $ per Tonne
Sanitary landfill	10 - 20
Secure Landfill:	
Wastes which are not acutely hazardous, including sludges	40 - 200
Highly toxic, explosive or reactive chemicals*	200 - 1000
Incineration:	
High BTU value, no acute hazard	100 - 600
High toxic, heavy metals	600 - 1500
Chemical Treatment:	
Acids, alkalines	100 - 300
Cyanides, heavy metals, highly toxic	200 - 1000
Resource Recovery	100 - 400
Deep Well Injection:*	
Oily wastewaters	30 - 500
Dilute toxic rinse waters	100 - 200

* Disposal may be prohibited according to provincial or federal statutes.

Source: Private discussions with recyclers and hazardous waste treaters.

6.0 ECONOMIC INCENTIVES

Financial incentives can tip the balance in favour of recycling when economic conditions are stable and favour the continuation of existing disposal practices. If economic rewards can be gained from recycling of hazardous waste, then why doesn't it happen by itself? The information required to develop technological innovations in recycling is often unavailable. If the information and technology are known, bringing them on line involves front-end capital costs. Neither regulations, nor changes making pollution control more expensive, fully address the question of the uncertainty and risks in capital acquisitions for recycling. Although recycling may pay off in the long term, uncertainty and the investment required will be critical in implementing and undertaking a recycling project.

These two elements suggest that firm size may be a critical factor in explaining those waste recycling projects which have occurred so far. Technological requirements, economies of scale, and capital costs of recycling are the main reasons why major advances may come to large, well-integrated firms and industries. The ability to innovate technological changes may require information provided by in-house engineers and scientists which are usually unavailable to smaller firms. Also, in a large, integrated and diverse operation, there is more opportunity to offset these costs to other more profitable production processes. Larger firms are able to raise long-term capital or plan over an investment time frame in which the profitability of changes in production can be demonstrated.

With these points in mind, the objective of market incentives can be seen. The purpose of the incentive is:

- to provide information and expertise;
- to reduce the capital costs of the facilities to promote recycling;
- to make recycled products more economically attractive in the marketplace.

The role of market incentives, therefore, must also be suited to different needs of industry. By reducing the uncertainty surrounding investment in recycling technology, it is possible to lower expected long-run average costs to industries

interested in undertaking these investments. If there is profit in recycling or waste minimization, the effect of market incentives is to make faster pay-out times and with a greater degree of certainty.

The role of the incentive is even more pronounced when the firm is small. Small firms are highly vulnerable to both investment uncertainty and capital costs, and may require additional stimulation such as information which large firms generate in-house, as well as capital incentives.

6.1 Identify Incentives

6.1.1 Tax incentives

The current Federal tax measures affecting the use of recycled material is presented in Table 6-1. It has been the practice of governments to encourage broader social goals through direct and indirect assistance. Tax incentives encourage generators of hazardous waste to invest in recycling and recovery equipment and, to a lesser extent, in research aimed at recycling techniques or technologies. When combined with other forms, tax incentive programs may be an efficient means of encouraging firms to make the required investments. Incentives within the Income Tax Act are in three basic forms: (Adamson, 1984) deductions from taxable income; (Ont. Min. of Env., 1985) refundable tax credits; and (Griffiths, 1983) flow-through shares and other fiscal concepts. Tax incentives can also be obtained in other taxing systems, taking the form of sales tax exemption under the Excise Tax Act and tariffs under the Customs Tariff Act.

Table 6-1

CURRENT FEDERAL GOVERNMENT ACTIVITIES

Income Tax Act

- Accelerated capital cost allowance (Class 8) would normally be available for new equipment purchases.
- Federal Income Tax Act accelerated capital cost allowance allows recycling control equipment to be written off in three years - disallows accelerated recycling equipment write-offs if they result in cost savings or high rates of return. (Classes 24 and 27)
- R & D expenditures are entitled to normal incentives. (Section 37)
- Normal investment tax credits available.
- Federal Income Tax Act allows increased rates of depreciation for assets required to open or expand a new mine and allows exploration expense write-off and extra tax deductions to encourage investment in raw resource production.

Excise Tax Act

- Equipment for recycling facility would normally qualify for sales tax exemption.
- Recycling equipment purchased by non-manufacturers for R & D purposes may not be exempt.
- Double taxation of a variety of recycled materials through the Excise Tax Act (e.g. ferrous scrap metal, rebuild product, tire retreading, oil re-refining, reusable containers).
- Exclusion from certain exemptions for containers designed for repeated use.

Customs Tariff Act

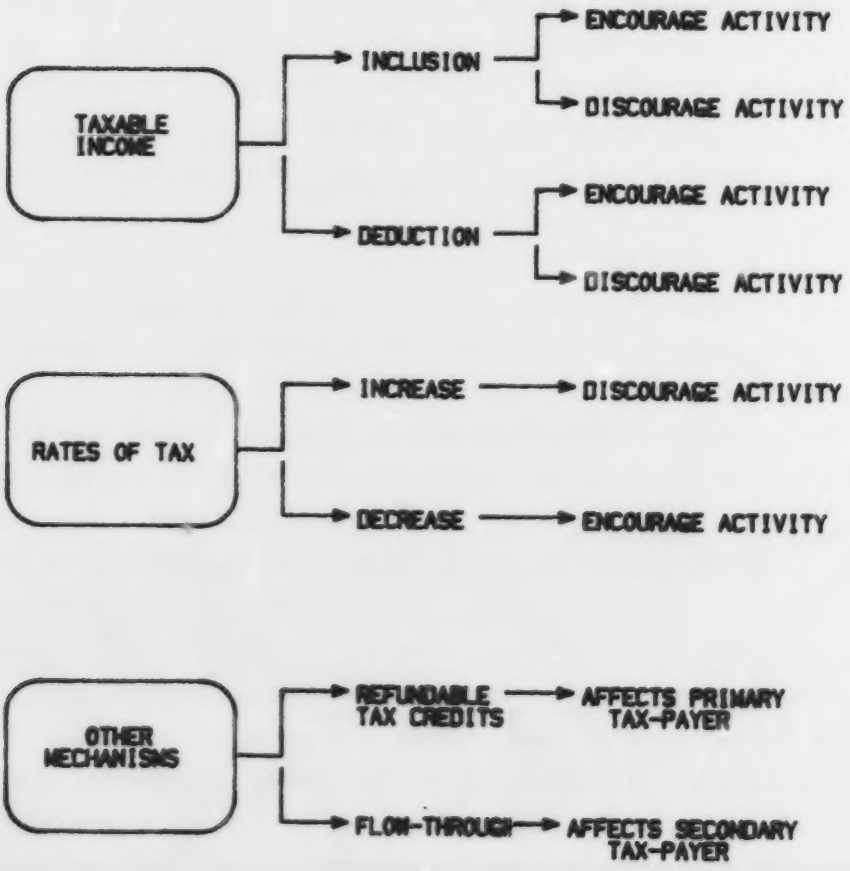
- All imported goods are assigned a tariff rate ranging from 1 to 35%.
- Canada - U.S. proposed Free Trade Agreement will eliminate all tariffs over the next ten years, starting January 1, 1989.

Income Tax Act: The Income Tax Act operates directly on the income-related activities of taxpayers, and does not directly affect the consuming activities of individuals. Although the Income Tax Act encourages certain types of economic activities, it does not attempt influence the manner in which the activities are carried out. There are three main mechanisms through which the Income Tax Act can influence the economics of recycling:

- through the definition of taxable income;
- through rates of tax applied to taxable income;
- other more specific mechanisms such as tax credits, etc.;

and these are shown below

INFLUENCE OF THE INCOME TAX ACT



There are specific classes of capital assets which may be deducted under the Income Tax Act. Accelerated capital cost allowance for Pollution Control Property (Classes 24 and 27) under this Act allows recycling equipment to be written off in three years (25%, 50%, 25%). It, however, disallows accelerated write-offs if they result in cost savings or high rates of return, and must have prior certification by the Federal Minister of the Environment. Although these provisions under the Income Tax Act were enacted to encourage industries to invest in pollution control equipment for compliance with pollution control legislation, recycling often results in cost savings as well as pollution abatement. Many of the applications under the accelerated cost allowance provisions have been rejected on the basis that the installation is not pollution abatement, but economic efficiency. Although the accelerated capital cost allowance for pollution control equipment may assist industries in complying with more stringent provincial pollution control standards, it does not act as an incentive for investment in recycling equipment. The addition of another class to deal specifically with recycling is required to encourage investment in recycling equipment. Favouring recycling equipment over conventional equipment would stimulate the interest in resource and energy conservation, clean technology and process efficiency.

Section 37 of the Income Tax Act allows taxpayers to deduct all qualifying current and capital expenditures for research and experimental developments conducted in Canada in the year in which they were incurred or in any subsequent year. For Canadian controlled private corporations eligible for the small business deduction in the year, the investment tax credit is up to 100 percent for R & D expenditures. Revenue Canada has established a special assessing and audit group to administer claims to provide refunds to R & D firms.

There are other accelerated capital cost allowance provisions that discourage recycling or reuse of wastes because they provide incentives to industries to use raw or virgin materials. Depletion allowances, costs of clearing and removing overburden, the Canadian Exploration Expense, all provide a substantial indirect barrier in that they provide for investment in raw virgin material at the detriment of recycled materials.

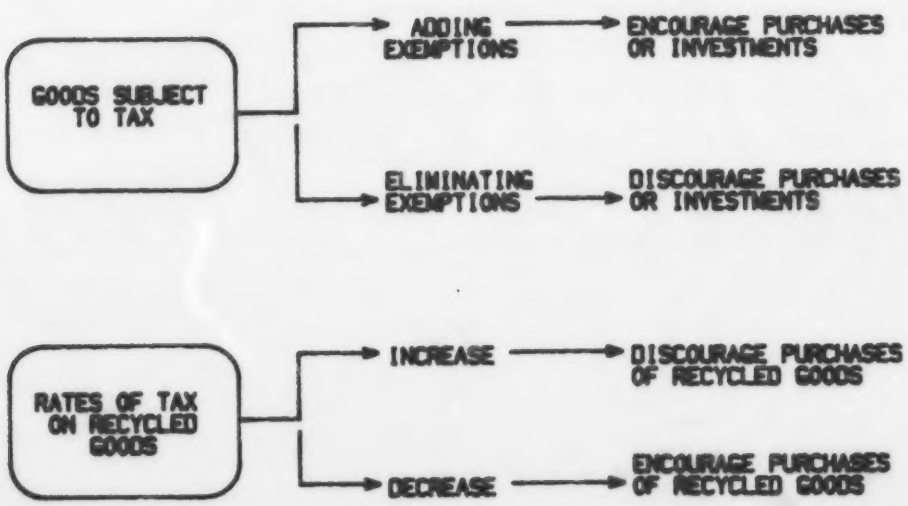
Excise Tax Act: Two main mechanisms that could be used to influence recycling using the Excise Tax Act are:

- defining or exempting those goods subject to tax; and
- adjusting the rates of tax to specific goods.

Under the Excise Tax Act, there is a degree of double taxation of recycled raw material. Under the Act, a consumption or sales tax is levied on all goods manufactured or imported into Canada. Double taxation occurs on a number of recycled materials including ferrous scrap metal, rebuilt products, tire retreading, oil re-refining and reusable containers. For example, re-refined oil is subject to double taxation: at the time the oil is consumed as a raw resource, and at the time it is consumed as a recycled commodity. Companies engaged in re-refining used oil are denied an exemption of federal excise tax on the oil produced. This has the effect of discouraging the wider use of a recycled commodity and the environmental benefits associated with it.

A federal rebate on the purchase of recycled materials would act as an offset to the double taxation problem plaguing recycled goods. The rebate would create a price advantage for recycled materials, and would provide some incentive for recyclers to seek out supplies of, or markets for, recycled materials. The impact on federal revenue is likely to be of a minor nature

INFLUENCE OF THE EXCISE ACT

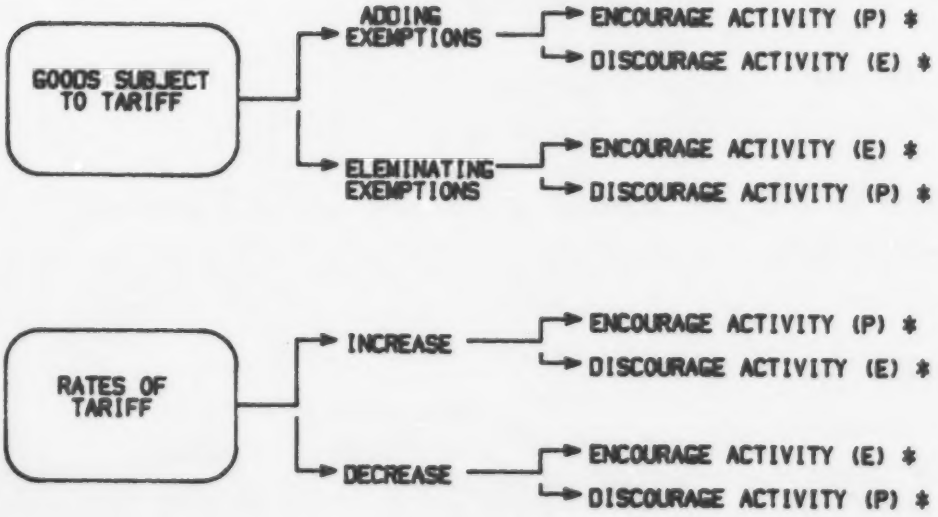


Customs Tariff Act: Currently the main mechanism influencing the economics of imports is through the Customs Tariff Act, in which all goods imported into Canada are assigned a tariff item. Although it is possible to change the duty rates on recycled goods or equipment used for recycling purposes, the proposed Free Trade Agreement may alter this considerably. Mechanisms that can be used to influence recycling using the Customs Tariff Act are:

- defining or exempting those goods subject to tariff; and
- altering the rates of tariff on specific goods.

More than 75 percent of Canada-United States trade currently moves free of duty (Dept. of External Affairs 1987)

INFLUENCE OF THE CUSTOMS TARIFF ACT



* NOTE: DEPENDS IF THE COMMODITY IS A RECYCLED PRODUCT (P) OR EQUIPMENT (E) USED FOR RECYCLING.

Under the Customs Tariff Act there is a wide spectrum of tariff items on imported goods and any price advantage and disadvantage may have to be offset by adjustment of tariffs in other areas. For example, increasing the tariff on recycled goods may have an impact of promoting more recycling in Canada. Tariff barriers may cause users of recycled materials to relocate in areas more favourable.

High U.S. tariffs continue to pose a serious barrier to the U.S. market and prevent Canadian firms from achieving the economies of scale to be competitive. In addition to high tariffs, escalating tariffs on specific products discourage the development of more sophisticated manufacturing in Canada. The existence of Canadian tariffs on imports from the United States is often costly to Canadian consumers. The proposed Free Trade Agreement is likely to have a significant impact on items now covered by the Customs Tariff Act. The Free Trade Agreement will:

- eliminate barriers to trade in goods and services between Canada and the United States;
- facilitate conditions of fair competition;
- significantly expand liberalization of conditions for cross border investment.

This agreement, when signed, will eliminate all tariffs in trade between Canada and the United States over a ten-year period. Both the United States and Canada will continue to apply their existing tariffs to other countries. Prices for a wide range of consumer goods will drop and investment spending for new plant and equipment will increase. Investment will probably flow more freely between Canada and the United States, and presumably some of the technologies and recycling climate now being stimulated in the United States will become available in Canada.

Table 6-2

FEDERAL GOVERNMENT TAX INCENTIVES

MEASURE	INCENTIVE	COMMENTS
Income Tax Act	Increase Capital Cost Allowance	Reduces cost of recycling technology and equipment
	Increase Investment Tax Credit	Reduces cost of equipment
	Increase incentives for recycling research and development	Will increase research and development
	Flow-through shares for recycling	Will provide funding for firms to acquire recycling equipment
Excise Tax Act	Impose an excise tax on goods containing virgin raw materials where recycled materials could be substituted	Would encourage recycling
	Remove double taxation on a variety of recycled materials	Removal of the excise tax will decrease the price of recycled goods and would encourage their use over virgin materials
	Sales tax rebate to purchaser of recycled goods	Would encourage recycling
Customs Tariff Act	Decrease duty rates on recycling equipment	Encourage the acquisition of recycling equipment

6.1.2 Direct Incentives for Recycling

Direct financial incentives can also encourage recycling of wastes, especially when economic conditions favour the continuation of existing waste disposal practices. Many of these programs can be applied to recycling projects, although usually they are part of a broader funding program, such as energy conservation. (Table 6-3)

The Development and Demonstration Resource and Energy Conservation Technology (DRECT) is administered by Environment Canada and Energy, Mines and Resources Canada. It will fund up to 50% of the total cost of an approved project, including equipment, buildings, installation, engineering and consulting services. When the project is completed, the developer can keep all equipment, technical data, designs, or patents resulting from the project. In return, the project proponent must make patents and technology available and must provide a comprehensive report on the project. Most projects to date have been directed to energy conservation. This program is probably the one most directly applicable to recycling projects.

The Industrial & Regional Development Program (IRDP) provides financial assistance to qualified companies that promote industrial innovation. The program provides support to viable projects at various stages of the innovation and business development process. Up to 75% of the project costs may be financed depending upon the type of project and the geographic region.

The IRDP program has provision for financial assistance of research and development programs, adoption of new or improved technology, as well as equipment and facilities, provided that the research is the elimination or reduction of pollution.

The Unsolicited Proposals (UP) fund, administered by the Federal Department of Supply and Services, is to provide assistance to anyone engaging in research and development. Up to 100% of the project costs are fundable. Capital costs

Table 6-3

COMPARISON OF FEDERAL ASSISTANCE PROGRAMS APPLICABLE TO RECYCLING PROJECTS

PROGRAM	CROWN CONTRIBUTION	TITLE TO RESULTS	ELIGIBILITY	SUPPORTABLE ACTIVITIES	RESPONSIBLE DEPARTMENT
DRECT Development of Resource and Energy Conservation Technology	Up to 50%	Company		Development, demonstration	Environment Canada
IRDP Industrial & Regional Development Program	Max. 75% of project costs[1]	Negotiable		Research, development, demonstration	Industry Trade & Commerce
UP Unsolicited Proposals Fund	100% of project costs[2]	Crown	No restriction	Research and development	Supply and Services
IRAP Industrial Research Assistance Program	Salary costs of technical personnel	Company	Most companies	Research	National Research Council
PILP (IRAP) Program for Industry - Laboratory Projects	Up to 100%[3]	Crown[4]	Qualified companies	Commercialization of Crown-owned technology	National Research Council

NOTES:
1. Depends on geographic region and type of project.
2. Capital costs are generally not eligible.
3. No limit, but Company is expected to contribute.
4. Company will be licenced to exploit the technology.

These are major programs. Support is also available in specialized areas from other Departments - e.g. Agriculture (AERD) and Energy, Mines & Resources (CREDA, FIRE, IERD, etc.)

are generally not eligible. This program was expanded in 1985 to allow projects that aim at demonstrating new technologies in operational settings. This program is specially targeted at small Canadian businesses.

The Industrial Research Assistance Program (IRAP) is a program administered by the National Research Council to encourage research and development in Canada. Under the IRAP program, scientific, technical, research and development of the National Research Council and various research organizations within the provinces assist the proponent in a range of industrial research developments in Canada. It covers the salary cost of technical personnel.

There are six elements in the program, including:

- advisory program on government assistance;
- an advisory program on existing technology;
- a short-term employment program to assist in industrial programs;
- a short-term experimentation program;
- a research development program for small, research and development projects;
- a research development program for longer term, higher risk projects.

A number of recycling programs have been funded under this fund, although they apply to most companies interested in economic development.

PILP (IRAP) This IRAP program element was initiated in 1975 by the National Research Council (NRC). It is designed to promote a more rapid transfer of results from NRC laboratories. The program is designed to help overcome barriers to industrial use of the research results of public and international laboratories by funding work that will advance development, allow better identification of the eventual product, expose the economic factors affecting the product or process, and identify its place and position in the marketplace.

Special Assistance for Small Businesses

Small businesses have historically had difficulty in obtaining the long-term, low interest rate financing available to large industries. This problem is as serious for recycling investments as for any other type of investment that small business might make. Barriers faced by small businesses include limited credit histories and relatively small capital requirements.

In the past, most loan guarantee programs have relied on the authority of the Small Business Development Agency to offer unqualified guarantees for the full loan amount for recycling investment.

Business Improvement Loans

Small businesses in Canada whose gross revenues do not exceed $2 million per year may receive guaranteed loans from chartered banks and other lenders to purchase fixed or movable equipment; to purchase or build premises; to modernize existing facilities; or to purchase land for the operation of businesses. The total loans outstanding to any one enterprise may not exceed $100,000 and loans may be secured over a ten-year period. The maximum interest rate that can be charged is bank prime rate plus one percent.

The Federal Government and the provinces have in place a funding mechanism under the Economic and Regional Development Agreement (ERDA). It covers all federal departments within each province which influence economic development. Under ERDA, a number of subsidiary agreements have been signed with the provinces providing for specific incentives such as interest-free loans of up to $60,000 to encourage the establishment, modernization or expansion of manufacturing and processing firms. Each province or region has specific programs or incentives under ERDA with varying terms and conditions.

The Federal Business Development Bank (FBDB) offers term loans to allow customers to acquire fixed assets such as land, buildings, machinery and equipment. The FBDB is a crown corporation that exists to promote and assist most types of businesses in Canada, either at the start-up stage or at some

other stage in their development. These loans are offered at competitive rates for fixed periods of up to five years.

Subsidies

Direct federal or provincial subsidies paid to firms involved in the acquisition of capital equipment for recycling is the final method for encouragement of installation of recycling equipment. Subsidies paid to firms in a given size category may be desirable if alternatives to disposal are limited or if the only alternative to recycle technology is costly "end-of-pipe" treatment. The recycling process becomes an integral part of the production process and, once adopted, must continue operating.

6.2 Evaluate the Effectiveness of Incentives

Allowing faster write-offs for recycling equipment under the Income Tax Act will reduce the discounted after-tax cost to the firm. The impact will be to encourage faster and more investment only if there is a demand for recycled materials. Incentives which promote Research and Development will help new or innovative recycling technology. The impact on such incentives will be to encourage investment where proven recycling technology exists or where there is a high demand for recycled products. Of major concern is the market demand for recycled goods. Current market demand for recycled hazardous wastes is poor and the entire recycled materials market tends to be cyclical.. A high priority must be placed on tax incentives which stimulate the market demand for these products. In the case of recycled paper or plastics, for example, the potential supply of these materials usually exceeds their demand. In the case of metals and glass, supply and demand are about equal.

One of the barriers to the recycling of hazardous wastes is the technology barrier. More effective methods should be used to intercept these materials in the waste stream and redirect them into the production cycle. Recognizing the market for hazardous wastes and the degree of double taxation of recycled goods, a Federal Sales Tax rebate providing it were appropriately targeted, would increase both the supply and demand of recycled products. A high

priority must be given to tax incentives which increase the demand for recycled materials. A sales tax rebate would create an advantage in price for recycled goods and would provide incentives for recyclers to secure supplies of and markets for all recycled materials.

The Customs Tariff Act provisions are not particularly attractive as an incentive and, because of the pending Free Trade Agreement, its usefulness as an incentive may be rather limited.

7.0 INFLUENCE OF INSTITUTIONAL STRUCTURES ON HAZARDOUS WASTE RECOVERY AND RECYCLING

Corporate policies and attitudes can have a major influence on waste management practices. For example, pollution control was initially treated as a cost of production with little attention to integration with the actual manufacturing process. Recently, several large integrated corporations have adopted policies for waste reduction which have proven profitable, and have resulted in major decreases in hazardous waste generation. The success of these programs and policies are due to a number of factors, which include the following:

- the policy is strongly supported from all levels of management throughout the corporation;
- employees at all levels are encouraged to suggest methods to reduce and to recycle hazardous waste;
- many of the waste reduction programs involve changes in the actual production process to facilitate recovery of recyclable materials;
- each of the waste reduction projects are demonstrated to be economically justifiable with a definable return on investment.

A second institutional factor which will influence quantities of hazardous waste available for recycling is vertical integration and corporate diversification. Larger corporations tend to diversify from their original product line for stability of supply of raw material or to provide a market for products currently being manufactured. Consequently, vertical integration most often results in a direct sales of products between subsidiary companies. This relationship may provide opportunities to recover and recycle materials between facilities. The extent to which recovery and recycle of wastes occurs between divisions of vertically integrated corporations depends on several factors which will be discussed below.

Yet another institutional factor affecting waste recycle decisions is customer perception. A major concern associated with using hazardous waste as a raw material is product quality and customer perception of the effect of recycled materials in the product. Assessment must be made to determine whether or

not product quality can be maintained by using recycled materials. Substitutions may not be possible in industries where there are high standards for product purity or product specifications. Customer acceptance of the product quality will be the ultimate test for usage of recycled hazardous waste. The effects of these factors on recycling of hazardous waste are assessed in more detail below.

7.1 Corporate Policies and Corporate Structure

Historically, management of waste streams has dealt with treatment and control of wastes as add-on processes. In essence, manufacturing or process groups within companies produced a product which was accompanied by a variety of waste materials. It then became the responsibility of the environmental control group to manage these wastes in such a way as to meet regulatory requirements. The costs to treat wastes using the "end-of-pipe" approach are substantial, both in terms of equipment required and in energy requirements. Consequently, environmental departments have been considered cost centres which make no contribution to profits. **Corporate policies which encourage "end-of-pipe" pollution control tend to be barriers to recovery and recycle of hazardous waste.**

The 1986 OTA survey of industry concerning hazardous waste indicated that rising costs and increasing difficulties associated with landfill usage were the most important factors influencing waste management decisions. These factors have influenced the policies and are reflected in the waste management strategies of several large corporations in the U.S. The policies adopted by senior management in these companies are designed to ensure that reduction of hazardous waste is a priority at all levels of the company. Management structures have been put in place to implement these policies and ensure that every effort is made to reduce quantities of hazardous waste requiring treatment and disposal. For example, several years ago, 3M Company recognized that waste management was a responsibility of all groups within the company. The generators of waste products were made responsible for minimization of wastes as well as manufacture product. 3M has achieved remarkable results in waste reduction as a direct result of shifting a share of the responsibility of

waste management to the manufacturing divisions. Many changes have been made to processes and increased profitability has resulted, returning over $190 million to the company in the first ten years of operation. In this case, corporate policy has had a very positive effect in reducing waste generation and in reducing environmental control costs.

In contrast, Royston (1982) suggests that industries "which are the economic headaches of industrialized countries" are those which "are at the top of environmentalist hit lists." These industries are also those which depend on low technology and which tend to show low profitability. For example, a strong correlation between profitability and a good record of pollution control was shown for 120 pulp mills in the United States (Royston, 1982). The correlation is illustrated in Table 7-1.

Table 7-1

CORRELATION OF POLLUTION CONTROL PERFORMANCE AND CORPORATE PROFITABILITY

Between	Correlation of Good Pollution Control Performance and Earnings per Share	Return on Equity	Return on Capital
% of plants with pollution control equipment	Significant*	Significant	Not significant
% of plants with advanced waste water treatment	Significant	Significant	Not significant
Subjective evaluation by Council of Economic Planning of pollution control effort	Significant	Significant	Significant

* 'Significant' means significant at the 95% confidence level

Source: Royston (1982)

Corporate policies may act as a barrier to recycle of hazardous waste, particularly in those corporations which have not recognized the cost savings and/or profit which can be derived by making waste management the responsibility of all employees.

The long-term responsibilities associated with disposal of hazardous waste in the U.S. may be onerous. Similar responsibilities for management of hazardous waste in landfills apply in Canada. In certain cases, the accounting for risks and liabilities associated with hazardous waste disposal may not be given sufficient weighting in corporate policy. Shell Oil Co. in the U.S. has recognized the significance of long-term responsibilities and feels that long-term risks are the most significant factor in making hazardous waste management decisions. This company has found that when both short-term and long-term costs are accounted for correctly, the costs for disposal are approximately the same as for other waste management options. Consequently, the option which provides the least or most acceptable risk in the long term will be selected. **Corporate policy which does not require assessment of long-term liabilities and risks may act as a barrier to recycling of hazardous waste.**

Corporate size and structure may have a dramatic effect on waste reduction and waste recycling within each company. In large corporations, size can act as a barrier to recycling of hazardous wastes by adversely affecting the following:

- decision-making and approval processes;
- communications and information transfer;
- availability of information on materials or wastes for recycling.

The complexity of decision-making and approval processes may involve a large number of individuals and groups. For example, at the early or conceptual stages of a project (waste management or process improvement), data and information inputs will be required from the process and manufacturing groups, technical and design engineers, purchasing groups and the environmental or pollution department. These groups will assemble the data in a format which is consistent with an overall project description consisting of feasibility studies and engineering designs. Once prepared, these studies will be reviewed and

approved, often by several levels of management and often with revisions at each level of approval. Clearly, this type of approval process requires careful and complete transfer of information and data at each stage so that competing alternatives can be clearly compared. It is conceivable that an obvious, but critical factor may not be given sufficient attention by those preparing the information. Final decisions for expenditure for specific waste reduction processes may be made by individuals with little or no knowledge of the specific process involved. If information and data is not communicated to this group in sufficient detail and with sufficient clarity, an otherwise successful project may never be implemented. The more levels of approval required, the more complex the decision making process and the more difficult it is to ensure that all factors are considered correctly by the decision makers. **The decision-making and approval process for project expenditures may act as a barrier to recovery and recycling of hazardous waste.**

Corporate size can also affect management of hazardous wastes due to inadequate communication systems and mechanisms. For example, one division of a company may stop using a particular product for one reason or another. Other divisions in the same company may continue to use this product. Unless a mechanism has been developed to ensure that the availability of surplus materials in separate divisions of the company are identified and communicated to purchasing departments, transfer of materials between divisions will be fortuitous. If the hazardous materials are not transferred between divisions, disposal of surpluses may be the option selected simply on the basis of least cost. **Unless mechanisms are developed and implemented to ensure good communications and information transfer between various corporate groups, there may be a barrier to the recycle of surplus hazardous materials between divisions of the company.**

Factors affecting the decision-making process and the types of decisions will differ dramatically from smaller companies to large corporations. For example, in smaller companies a small number of individuals will be involved in making decisions concerning waste reduction operations. These individuals, in most cases, will be much better informed on plant operations and on the economic viability concerning the particular waste reduction option being considered.

However, smaller companies generally do not have the resources nor the personnel to undertake detailed and extensive evaluations of several options for waste reductions. In this case, **corporate size may prevent small companies from identifying and implementing more effective hazardous waste recovery and recycle projects.**

Corporate management structure can also have adverse effects on the implementation of hazardous waste recycling and reduction. The following factors may influence corporate management on recovery and recycle of hazardous materials:

- management decisions may be based on maximizing performance of individual divisions in favour of the total corporate picture;
- decision-making autonomy of line managers may override corporate policy with regard to hazardous waste management;
- a corporate group charged with the implementation of corporate waste management policies can have a very positive effect.

Separate divisions of a company have defined responsibilities. Managers of those divisions have a specific duty to see that their division fulfills its responsibilities. In so doing, actions may be inadvertently taken which adversely affect the performance of other divisions and/or the company as a whole. In the extreme case, environmental engineers may be assigned to control wastes emitted from the "end-of-pipe" while production decisions, including those resulting in waste generation, are being made without concern for pollution control. Similarly, when the technical or engineering department is charged with the redesign of a product or process they may unknowingly have insufficient information on the operating conditions or constraints. If the design were to incorporate features which impeded smooth operation, otherwise useful waste reduction measures may be by-passed by operations personnel. These would be very rare occurrences, but serve to illustrate the need that decisions not be made in isolation. In each of the examples above, it is conceivable that the efficiency of operations may adversely affected. **Corporate management structure may act as a barrier to efficient recovery and recycle of hazardous wastes unless management decisions are based on maximizing overall performance of operations.**

Responsibilities for decisions and the decision-making process will depend on the management style and structure. In certain cases, plant managers are autonomous and make their own decisions without significant input from corporate headquarters. It is conceivable that, although corporate policy stipulates recovery and/or recycle hazardous waste whenever possible, a production manager may fail to implement this policy if he feels there is insufficient incentive. Conversely, decisions of a major nature may require corporate approval. If a production manager is unable to convince higher levels of management that an opportunity to reduce hazardous waste is desireable, viable and profitable, implementation of a valuable waste reduction or recycling project may be thwarted. Clearly then, **the decision-making processes and authorizations may act as a barrier to recycling and recovery of hazardous waste.**

It should be evident from the foregoing that there is a need for a strong corporate commitment for waste reduction among all groups responsible for carrying out corporate policy. This strong commitment must include distribution of responsibility for implementation of such policies, and a means to establish cooperative efforts to implementation.

The need for clear lines of communication to ensure information flow both to the decision-makers and to the operations/design groups in corporations should be evident. At DuPont, a policy to reduce waste has been implemented by a corporate committee charged with the responsibility to ensure that all operations reduce waste generation rates. In forming the corporate committee, senior management sent a message to operations and design groups that the policy has top priority, approval and support. It further establishes that there are clear lines of communication to get projects approved. Finally, there is a need to ensure that incentives for waste reduction include the element of profitability. This element of profitability will ensure that all methods for waste reduction have been examined carefully before selection of a specific technique.

7.2 Vertical Integration

Vertical integration is the practice of diversification of operations by large corporations to ensure an adequate supply of raw materials, markets for products and transportation systems to get the products to final markets. The effect of vertical integration is to ensure corporate control over raw material and component source and pricing, thus reducing uncertainties for the purposes of corporate planning. Vertical integration may act to stimulate hazardous waste reduction or recycling in some cases. In other cases **vertical integration may be a major barrier to recovery and recycle of hazardous waste.**

Opportunities for waste recycling resulting directly from vertical integration are exemplified by a highly successful program operated by Allied Corp. in the U.S. One plant, located in Illinois, manufactures uranium hexafluoride and other fluoro chemicals. The waste water from this plant is acidic and contains soluble fluorides. In order to meet effluent water quality standards, pH is adjusted using more than the theoretical requirement of lime. Addition of lime also reduces fluoride contaminants to levels required by the wastewater discharge permit. Initially, large quantities of solids were generated and disposed in large ponds on site. It very quickly became obvious that the land disposal of the spent lime and calcium fluoride solids would rapidly consume all the available land on which the plant was situated. A second plant located in Louisiana manufactured hydrofluoric acid using fluorospar (calcium fluoride) as a raw material. This second plant was able to take all of the waste calcium fluoride and some materials from existing disposal cells as a source of raw material. Approximately 8000 tonnes of synthetic fluorospar are produced annually while lime consumption is reduced by about 1,000 tonnes annually. (The price for fluorospar was approximately $175.00 per tonne). This opportunity for recycling of a hazardous waste may not have occurred except for the vertically integrated operations of Allied Corp.

Vertical integration may also act as a barrier to deter off-site recycling. For example, if the demand for raw materials can be fully satisfied from within the vertically integrated company, it is extremely unlikely that purchases of recycled raw material will be made from an outside source. Although a supply

of recycled materials may be available locally, corporate policies in the vertically integrated company can ensure that this source of material is not used.

In certain regions of Canada there is a regional integration of industry. Often industries manufacturing related products are located in close proximity. For example, the petrochemical industry in Canada is located primarily in Alberta and the Sarnia region of Ontario. These industries rely on large quantities of natural gas and petroleum liquids which are either produced nearby or are available through the regional infrastructure of industry which has been built up over the years. There may be opportunities for recycle and/or reuse of wastes from one company to another in regions where industries use or produce related products.

7.3 Raw Material Procurement Policies

A major consideration in the use of recycled materials as feedstock is the affect these materials may have on final product quality. Some industries such as the electronics and pharmaceutical manufacturing industries have very stringent quality control standards for their products. It is extremely critical in these industries to ensure that raw materials meet very stringent requirements so that the production process is not disrupted and so that there is not an increase in "off-spec" product. The high raw material quality required coupled with the high profit margins in the product for the electronics and pharmaceutical industries suggests that these industries are not likely to use recycled hazardous materials. However, these industries tend to generate hazardous wastes meeting relatively high quality standards. These wastes may be suitable for recycle to industries with less stringent raw material quality requirements.

Changes in feedstock have been identified with the following perceived or real risks by industry:

- recycled materials may adversely affect product quality;
- recycled material may adversely affect market for product, even though the product meets all quality specifications;

- product specifications of customer may prevent the use of recycled materials e.g. government contracts.

These factors tend to increase the risk of using recycled materials as a raw material. Since corporate decisions are usually made to reduce risk, these considerations will heavily disfavour use of recycled materials as raw materials.

Raw material procurement policies can present barriers to recycle of hazardous wastes either due to very high quality requirements or perceived effects on product quality.

7.4 Product Quality

The affect that recycled materials have on product quality or perceived product quality is a major deterrent to their use in manufacturing. Although it may be demonstrated that there will be no variation in product specifications or quality, customers are often reticent to accept products containing recycled materials. There appears to be a fear that some non-specified quality may affect the performance of the material. Consequently, industry is reticent to implement changes which will reduce their market share, even if only temporarily. The power of the customer to specify product quality is a major deterrent to use of recycled materials. This is particularly true of government purchases in which product specifications are very stringently specified.

7.5 Perceptions of the Hazardous Waste Industry

Hazardous waste facilities tend to be perceived as "fly-by-night" operations, particularly those operations which are concentrating on recycling of wastes. This perception by generators of hazardous wastes, or potential customers for recycled hazardous wastes tends to act as a major barrier to recycling.

Although recovery and recycling of lubricating oils tended to operate under the same perceptions during early stages of development, this industry has become a viable and respected. This is partially due to the fact that there is a large demand for automotive products. In addition, these companies have constructed

facilities which are bona fide industrial operations. As the hazardous waste disposal industry gains more credibility, hazardous waste recycling will also become a more viable option.

7.6 Summary of Institutional Barriers

Institutional Barriers to recovery and recycling of hazardous waste include the following:

- Corporate policy which
  - encourages "end-of-pipe" pollution control;
  - does not recognize the cost savings/profit which can be achieved;
  - does not account for long term risk/liability associated with disposal.
- Corporate size which
  - requires several levels of approval for capital projects;
  - requires special communications and information transfer systems for efficient use of resources.
- Corporate management practices which
  - do not use efficient communications and information transfer;
  - whose policies do not provide sufficient incentive for autonomous managers.
- Vertical integration which may lead to protection and control of the markets or raw materials supply, effectively eliminating recycled materials.
- Raw material procurement policies which require materials of higher specifications than achievable using recycled materials.
- Perceived lower product quality for materials manufactured with recycled materials.

8.0 LEGISLATIVE BARRIERS AND INCENTIVES

The regulatory climate of the late 1970's and early 1980's provided little incentive, either direct or indirect, for the innovation and capital investment required to minimize hazardous waste generation or recycle wastes which were genenerated. Disposal of these wastes was easy and inexpensive for the following reasons:

- enforcement of environmental legislation was generally ineffective;
- standards varied from province to province and within the provinces;
- landfilling and discharge to sewers were unregulated;
- transportation of hazardous wastes was inexpensive and poorly regulated.

In recent years, most provinces have proposed or introduced legislation relating to hazardous wastes. The main objective of this legislation has been to ensure the safe disposal rather than to encourage waste minimization. At the same time, federal and provincial legislation has been developed to regulate the transportation of dangerous goods. To some extent, recycling has been encouraged by making the disposal of hazardous wastes more difficult and expensive. However, this "incentive" is indirect and therefore an ineffective incentive for recycling.

A number of administrators interviewed during this study commented that recycling is simply a matter of economics and that "if it will make money, it will be done." However, this approach ignores the conclusions reached in this report as well as the barriers identified above. The fact that more than potential profitability is required is reflected in the lack of investment in recycling that has occurred in recent years despite the introduction of special provisions for hazardous wastes in many provinces.

To achieve an effective waste minimization program, the barriers identified above must be removed and the following incentives must be implemented:

- protective provisions must be developed for recyclers of hazardous wastes;
- specific programs with an adequate regulatory staff allocation must be targeted for waste minimization; (This must be combined with grants and loans designed to assist new technology in this area.)
- specific allowances must be made for small generators.

Again some movement has been made in this direction by the provinces. However, waste minimization will not be maximized unless a "hands-on" approach in evaluating the industries involved, so that an appropriate combination of regulatory, administrative and economic incentives are used to achieve the desired results.

In the following subsections, the regulatory barriers to recycling and waste minimization are examined. The final subsection will consider steps that could be taken in legislation to directly encourage recycling, and will look at how specific recycling programs in Canada have been, or can be, implemented.

8.1 Legislation Regulating Disposal and Transportation of Hazardous Waste

Enforcement of pollution control legislation across Canada has generally been a low priority. This is because agencies responsible for enforcing this legislation have preferred to negotiate with polluters rather than prosecuting them. The result has been that permits for waste disposal have often been violated. As well, many disposers of wastes - particularly hazardous wastes - have simply not been caught. For example, a study conducted at the beginning of this decade (Adamson, 1984) concluded that in Ontario:

> "The actual value of legal fees and fines to a firm may be very low because a polluting company has a relatively small chance of getting caught, being prosecuted, being convicted and if convicted, sentenced with a large fine."

In B.C., a task force investigating enforcement efforts by the province in 1980 (Fraser River Task Force, 1980) concluded that:

> "Enforcement of permits and orders was lacking on many occasions and this proved to be a serious problem when the Task Force came to investigate [a] company. Although a company would be in violation of a permit for, in some cases, two or three years, no legal action had been taken by Waste Management Branch. This resulted in almost tacit approval by the Branch and caused problems for the Task Force when it came time for the decision to lay charges because of the 'due diligence' rule. Another problem centered around the actual finding of violations of permits by Waste Management Branch staff and the reporting of same on compliance checks. The [Task Force] teams would constantly encounter major violations which were easily identifiable yet would observe no record of non-compliances of a permit which caused a deadly toxic substance to enter the Fraser River. Three days after the team visited one site, two Waste Management staff members visited the same site and reported no violations. These violations are still continuing today. The Task Force also observed many instances of lack of enforcement of specific orders issued by Waste Management staff . . . wording on some of these orders proved to be too vague to enforce, thus making them literally useless."

The laxity in enforcement has also affected the response of the courts to environmental offenders. A report prepared by the Law Reform Commission of Canada (1985), reviewed prosecutions under the Federal Fisheries Act and concluded that:

> "Particularly in recent cases, the courts have been reducing sentences as a result of government negligence or laxity. In R. v. Suncor Inc., an Alberta Provincial Court fined the company $8,000 for a violation of section 33 of the Fisheries Act by depositing grease and oil into the Athabasca River. The maximum fine is $50,000. Horrocks J. stated that he took into consideration the Alberta government's failure to control violations by the company over the past fifteen years. "If the government watchdogs aren't going to get worried" he stated, "then there doesn't seem to be a need for the company to get worried."

In discussions with administrators across the country, many felt that there were many small generators of hazardous wastes who were continuing to slip through the regulatory net. Many simply did not have the increased staff necessary to enforce new hazardous waste provisions. For example, in Quebec, consideration is now being given to exempting small generators from the requirements of the

Hazardous Waste Regulation because it is impossible to monitor and enforce more than the largest generators, without an increase in staff.

Without adequate enforcement, generators will have little incentive to do more than continue their old practices. **It is recommended therefore that sufficient staff be hired to effectively enforce hazardous waste regulations and that, in the words of the Fraser River Task Force, that the provincial ministries "make a major attempt to change the past philosophy . . . from non-enforcement to enforcement."**

8.2 Variability of Environmental Standards

Provincial pollution legislation is generally characterized by a permitting system which allows administrators discretion to set standards on a site-specific basis. As a result, standards vary from province to province, as well as within particular provinces. This is in contrast to American legislation which spells out detailed standards for specific industrial pollutants.

The provincial legislation which has been proposed or implemented to deal with hazardous wastes continues to allow a great deal of discretion in the hands of administrators to permit disposal. This discretion has the advantage of permitting a wide range of solutions to a problem, including recycling and waste minimization. However, this advantage is outweighed by the uncertainty which is created by failing to identify provincial standards for hazardous wastes generated by particular industries. As discussed above, regulatory certainty is required before the innovation required to develop waste minimization will occur.

In a situation where standards are negotiated (making it unclear where competitors stand and what the future will bring) generators will continue to make the incremental changes necessary to meet regulatory requirements rather than exploring alternatives.

To some extent, new hazardous waste legislation has addressed this problem. The bottom line has been made clear to some generators. For example,

generators of PCB's know that they have few options for disposal of this material.

However, many generators are still not clear on what their options are. The stringency of on-site disposal of hazardous waste is generally more relaxed than disposal of these wastes off-site. In B.C., an on-site disposer must receive approval in the same manner as a general hazardous waste disposal facility. However, the approval of those sites on a site-specific basis will likely mean considerable variation in the standards set.

Experience has shown that where standards are set consistently for an entire industry throughout the country, the greatest incentive is created to recycle. An example is the landfilling of tetrachloroethylene in the Maritimes. In the mid-1980's, public concern was raised about the landfilling of tetrachloroethylene from dry cleaners. Employees of environment ministries from Nova Scotia, Prince Edward Island and New Brunswick approached a company which was already recycling solvents and convinced it to start a pick-up program from dry cleaners in the three provinces. They then worked with representatives of the dry cleaning industry to ensure its cooperation. Rather than gradually reducing the availability of landfills to dispose of tetrachloroethylene, New Brunswick, through legislation and the other provinces through policy, prohibited the landfilling of this material. As a result, there was almost complete participation in the recycling program.

Where it is possible to develop a province-wide standard, generators will understand that they are being treated equally and also appreciate the ultimate goal of the agency involved. **It is recommended that provincial and possibly national standards be developed for hazardous wastes produced by specific industries.**

8.3 Regulation of Landfilling and Disposal to Sewers

As discussed earlier in this report and by other authors, the availability of cheap landfilling and other means of disposal is likely the single most important

disincentive to recycling of hazardous wastes. Dr. Paul Palmer (1982), who is employed in the chemical recycling industry in the U.S., states that:

> "In the recycling business, the government is a major influence. One of the best things the government could supply, aside from tax breaks, is the legal climate to ensure that recyclable chemicals are not easily and cheaply discarded instead."

Until recently, regulations in Canada did little to address this disincentive. The majority of hazardous wastes were either landfilled or pumped down sewers or into waterways often totally unregulated.

The publicity about contamination of landfill sites in the U.S. in the mid to late 1970's created some public pressure in Canada to regulate hazardous wastes. More importantly, it alerted administrators to the potential time-bombs that existed by ignoring the hazardous waste problem.

In a relatively short time span, both the federal and provincial governments took the initiative to require special treatment of hazardous wastes. In 1979, Environment Canada established a task force with representation from the federal and provincial governments and industry to define which wastes would be considered to be hazardous and which would therefore merit special treatment. The federal government's objective in this exercise was to find a definition that would be accepted by provinces across the country rather than to introduce federal legislation regulating these substances.

Most provinces responded by drafting or introducing specific legislation to identify hazardous wastes and make special provision for their disposal. Given the complexity of the hazardous waste problem, it is not surprising to find that the approach is different in every province.

The federal government has not introduced any legislation regulating the disposal of hazardous wastes, apart from its control of PCB's under the Environmental Contaminants Act. Although there is an argument that Ottawa has the constitutional authority to regulate these substances, it has chosen to defer to provincial jurisdiction (Castrilli, 1982). Rather, it has taken non-regulatory initiatives in relation to hazardous waste such as establishing the

Task Force on Hazardous Waste Definition, as well as controlling hazardous wastes at federal facilities and creation of the Canadian Waste Materials Exchange.

Provincial Legislation

Under the Constitution Act (1867, as amended), provinces have been given the powers necessary to regulate disposal of hazardous wastes occurring within the province. The provinces can legislate with respect to property and civil rights under Section 92(13) and regarding all matters of a merely local or private nature under Section 92(16).

These powers have been used in the latter half of this century to regulate pollution to air, water and land. Without exception, this pollution legislation has been concerned with controlling the end product or discharge rather than the process by which it is created. The logic in this approach is, of course, understandable. It is much easier to regulate and monitor an end product than it is to attempt to influence the process by which the waste is generated (although the process is indirectly influenced by the standards set). As well, the abundance of water and available land in Canada has meant that there has been little incentive to force producers to reduce the waste generated or its toxicity.

The steps taken by some provinces in the last decade to regulate special wastes have simply been an extension of this "end-of-pipe" approach. If the waste falls within the designated definition, the producer must now dispose of the waste according to the particular requirements of the province. Nevertheless, to the extent that it is now more difficult to dispose of these hazardous wastes, producers will have an incentive to find ways to minimize these materials, including recycling.

A significant proportion of hazardous waste has been virtually unregulated because it has simply been placed into sewer systems or trucked to landfills without authorization. Provincial legislation has therefore focussed on ways to

identify the generators of toxic wastes and to change the way in which these wastes are disposed.

The success of these programs depends heavily on the enforcement of new provisions. Are all generators, particularly the small ones, now being identified? Are landfills being properly controlled to ensure that hazardous wastes are not being disguised as harmless refuse? Without answers to these questions, provincial governments cannot assess the effectiveness of their programs. For example, there is a suggestion that many Ontario dry cleaners may be illegally dumping their waste tetrachloroethylene rather than recycling it. If this is correct, the lack of enforcement is probably serving as the strongest disincentive to recycling.

Provincial hazardous waste legislation will be considered under the following headings:

- definition;
- identification of generators;
- special disposal requirements.

Definition

As described in Chapter 1 of this report and earlier in this chapter, the definition of hazardous waste varies from province to province. As a result, the number of producers which are subject to the special requirements relating to these wastes and who therefore may have more incentive to recycle will also vary. However, the effect of these differences on the volume of wastes requiring special treatment in each province is beyond the scope of this study.

It is therefore recommended that an analysis be conducted of the toxic waste in each province which is excluded because of the way in which such waste has been defined. If substantial amounts are being omitted, steps should be taken to standardize the definition. Where minimization or recycling of a hazardous waste is possible, it should be included in the definition of hazardous wastes.

Identification of Generators

A number of provinces, including Quebec and Ontario, and more recently Alberta, Manitoba and B.C., have instituted registration programs for identification of hazardous waste producers. Such a program has the advantage of alerting generators - particularly small ones - to the introduction of new legislation or policy relating to hazardous wastes. It also plugs the largest loophole in any waste management program - knowing who is generating waste. Once this is determined, it is relatively easy to trace and therefore to regulate the disposal of the wastes being generated. Until registration takes place, it is possible for many small generators to escape detection and to continue dumping wastes in an unsupervised manner. Requiring registration and imposing penalties for those who don't raises the stakes for those considering illegal dumping. The effectiveness of registration will therefore depend on what happens to those who evade this process. It also requires a commitment of regulatory staff and money to ensure that the broadest net possible is cast.

At least one administrator has commented that the amount of staff time required to organize and update this information outweighs its usefulness as a tool for monitoring waste streams and educating generators. For example, B.C. alone expects to register anywhere from 4,000 to 8,000 generators when it begins registration over the next couple of months. As of February, 1988, Ontario had registered 12,000 generators with 50 to 60 new registrations every week. A total of 25,000 waste streams have been registered in Ontario. This may be true where staff size is so limited that other important aspects of the program cannot be dealt with. However, it would appear that effective management of hazardous wastes, including waste minimization, cannot occur unless all generators have been identified. Without registration and a corresponding manifest system, many toxic waste generators will continue to slip through unregulated.

Another issue relating to registration is who is excluded. For example, in Alberta, hazardous waste generators who dispose of their waste off-site must be registered and those who dispose of their wastes on-site do not. Although those excluded have to comply with the licensing, monitoring and reporting

requirements of the Clean Water Act, some may feel little or no pressure to change their existing practices.

It is recommended that all provinces that have not done so implement a registration system and that sufficient staff be allocated to carry out this task.

Disposal

Most provinces have increased the regulation of hazardous wastes. In general, this has meant a specialized permitting process for generators of hazardous wastes and for facilities accepting these wastes. As with preceding pollution control legislation, a large amount of discretion is granted to the administrator in the requirements that must be met.

The extent to which new hazardous waste provisions will encourage recycling depends on a number of factors:

- the increased difficulty of disposal;
- the increased cost involved;
- the commitment shown by the province involved through staffing for enforcement and direct contact with the industry.

Some provinces have required that all hazardous waste producers utilize a special provincial facility designated for that purpose or dispose of the substances on site under conditions as stringent as those found in the provincial facility. For example, B.C. has introduced regulations under the Waste Management Act which will take effect in April, 1988, preventing producers of more than 5 kg or 5 L of "special" waste from using an method of disposal other than facilities approved for this purpose. No fees have been set yet for a provincial facility, however they will be significantly higher than existing landfills. The Chairman of the B.C. Special Waste Advisor Committee, has indicated that the increase in fees is designed to encourage recycling, while not being so prohibitive as to encourage small generators to dispose of their wastes surreptitiously (Boyes, 1988).

In Alberta, disposers of such wastes on site are licensed, monitored and controlled under the Clean Water Act rather than by the Hazardous Waste Regulation. As a result, producers may or may not be more inclined to on-site disposal (which already accounts for a large portion of disposal of these wastes) as regulation of disposal in provincially approved or accepted facilities becomes more stringent or costly.

In Saskatchewan, where the majority of hazardous wastes are deposited in industrial and sanitary landfills (Currie, 1985), plans to establish a provincial hazardous waste management system are being prepared. Hazardous waste producers must obtain provincial government approval before disposal into municipal or industrial landfills.

Manitoba has proposed that producers either dispose of hazardous waste at a hazardous waste facility or in some other manner approved by the Director. However, this section of the Dangerous Goods Handling & Transportation Act has not as yet been proclaimed nor has a facility been constructed.

Both Ontario and Quebec have a range of facilities which have been approved to accept hazardous wastes. Disposers of hazardous wastes must also be licenced. Both provinces have taken the lead in regulating hazardous wastes, through registration of generators, development of a manifest system and special licencing for disposal facilities. Ontario has licenced one facility at Sarnia for disposal of certain hazardous wastes and is currently planning the construction of a new toxic waste disposal facility. Quebec has also licenced one facility which has been specifically designated to accept hazardous wastes.

No hazardous waste facilities have been created in the Maritimes. In New Brunswick, hazardous wastes are regulated in the same way as other wastes under the Clean Environment Act. This is largely because of the perception that the amount of these wastes is too small to require special licencing and/or facilities. A study done by New Brunswick's Department of Environment in 1982 identified an annual production of 285 tonnes of waste requiring special

treatment. This is in contrast to an Environment Canada study in the same year that found that 46,885 tonnes of hazardous wastes were being produced annually in that province. This highlights the importance of defining hazardous wastes to ensure that the goals of a particular program are met.

In Nova Scotia, an industry-specific approach is being utilized. In 1987, enabling legislation entitled Dangerous Goods and Hazardous Wastes Management Act was introduced to allow development of regulations to implement the recommendations of a Task Force on Hazardous Wastes. One regulation relating to petroleum storage has been implemented and two more dealing with waste oil and asbestos are under consideration. No regulations exist with respect to hazardous wastes generally. By contrast, B.C. has developed general hazardous waste regulations as well as specific provisions for particular kinds of hazardous waste.

In provinces the size of the Maritime Provinces and in the Yukon and North-west Territories, major hazardous waste generators are well-known to regulators. However, changes in the approach used by generators cannot be expected without political support in the form of legislation and regulations. An example of one method used in the Maritimes to "encourage" recycling is discussed above.

To compliment legislation requiring disposal of hazardous wastes in specially permitted landfills, some provinces, such as B.C. and Quebec, have also prohibited generators from diluting or mixing these wastes to avoid the special requirements for toxics. Some municipalities have also used their jurisdictions to regulate substances deposited to sewer systems and landfills within the boundaries of the municipality. For example, one study (Adamson, 1984) reports that:

> "Pretreatment sewerage by-laws in Ontario . . . have developed pretreatment standards for different waste streams discharged into a municipal sewer. These standards do not cover every category . . . and may be open to inconsistent application and enforcement."

Apart from establishing pretreatment standards, municipalities have also passed by-laws requiring disclosure of wastes manufactured within the municipality, and

in Ontario have attempted to prohibit the establishment of hazardous waste facilities. Such by-laws can serve as an additional check on identification of generators as well as illicit disposal of hazardous wastes.

On the basis of the above, it is recommended that:

- **disposal of hazardous wastes be limited to specially designated facilities and that adequate enforcement be allocated to ensure that regular landfills and sewage systems do not continue to receive hazardous wastes;**
- **mixing and dilution of hazardous waste to evade hazardous waste regulation be prohibited in all jurisdictions;**
- **municipalities be assisted in developing by-laws to prevent deposit of hazardous wastes to local landfills and sewage systems.**

Some provinces have exempted a recycler of hazardous wastes from all requirements of their hazardous waste regulation. The extent to which this works as an incentive depends, of course, on how onerous the disposal requirements are. As one administrator said, the effect may be largely psychological.

In order to prevent such an exemption from being used as a loophole, Ontario has a very restricted definition of what can be considered to be recyclable. Provinces such as Manitoba and Alberta, where it is possible to have a more "hands-on" approach with industry, have exempted those recycling, reusing, or reprocessing wastes from the requirements of hazardous waste regulations, including transportation. By contrast, B.C. has defined recycled material fairly closely in its Regulation (which took effect April 1, 1988) to prevent the kind of situation which occurred in the U.S., where everyone declared himself to be a recycler to avoid strict disposal requirements. Recycling facilities will require special permitting under the Regulation; however, the conditions will be relaxed to encourage recycling.

A number of provinces have also exempted the transportation of hazardous recyclable wastes from manifest requirements. For example, in Alberta, companies which produce recyclable wastes must register as generators; how-

ever, they are exempt from manifest requirements when transporting wastes for recycling.

An assessment of the incentive for recycling provided by such exemptions is outside the scope of this study.

8.4 Transportation of Hazardous Wastes

The transportation of hazardous wastes was virtually unregulated until recently. This made it possible for generators of hazardous wastes to truck away their problems.

This has become increasingly difficult through the recent introduction of federal and provincial legislation regulating the transport of dangerous goods.

In 1980, the Federal Government introduced legislation governing the transportation of dangerous goods, including hazardous wastes. Under the Transportation of Dangerous Goods Act, hazardous wastes are followed using a manifest system from the generator to their ultimate destination.

This legislation had little practical effect until 1985 when Regulations passed pursuant to the Act were promulgated. The Act is comprehensive in that it deals with all means of transportation and covers a broad range of dangerous goods including nine classifications of wastes. As well, it covers storage of such goods, where the storage is in the course of transportation.

Other federal legislation, including the Aeronautics Act, the Atomic Energy Control Act, the Canada Shipping and the Canadian Transport Commission Regulations for the Transportation of Dangerous Commodities, also regulate to some extent the transport of hazardous wastes. However, the TDGA Regulations prevail wherever there is an inconsistency.

Of particular relevance to the recovery of hazardous wastes is Section 2.4 of the Regulations which exempt from the requirements of the Act goods being

handled, offered for transport or transported solely within the confines of a manufacturing or processing facility as long as public access is controlled.

The federal government has delegated the regulation of all intra-province hazardous goods transportation to the provinces, while maintaining control over shipments between provinces or out of the country.

All provinces have introduced complementary legislation, and are using a manifest system for hazardous wastes. The effect of legislation requiring manifests has apparently increased the cost of shipping hazardous wastes. In addition, a well regulated manifest system makes it more difficult to dispose of wastes surreptitiously and may receive special treatment because of their handling requirements. Like the increased regulation of disposal, the introduction of a manifest system has likely been an indirect incentive for waste minimization.

It is therefore recommended that a manifest program be implemented in all provinces where this has not as yet occurred.

Some authors have recommended that a manifest system could be utilized to assess the recycling potential of the waste being transported. Under such a scheme, a generator would be required to indicate whether the waste had the potential for recycling and why it wasn't being recycled. This would provide additional information upon which a specific waste minimization program could be developed.

One jurisdiction which has placed an onus on waste generators to recycle is California. Under state legislation, Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes, a list of "recyclable" toxic wastes has been established. Where a waste generator produces a waste on this list, it must justify why the waste is not being recycled before other means of disposal will be allowed. Even if other means of disposal were not prevented before a generator discharged its "recycle" onus, a requirement to assess the recycling potential of hazardous wastes could cause generators to consider other options. **It is therefore recommended that the practicality of requiring generators to**

indicate the recycling potential of a hazardous waste on the manifest used for transportation be assessed.

8.5 Protective Provisions for Recyclers of Hazardous Wastes

Little information exists with respect to the difficulties which are encountered by industries wishing to recycle hazardous wastes. However, the following issues have been identified:

- confidentiality of information for proprietary processes;
- protection of those using recycled materials i.e. product quality assurance;
- licensing requirements to operate a hazardous waste management facility (with all attendant extra costs).

Confidentiality

Generators may be unwilling to work with regulators to develop costly waste minimization programs if they feel that the information will fall into the hands of their competitors. In New York and California, where regulators are actively involved in encouraging such programs, State legislation has been introduced to protect the confidentiality of the information produced. This includes severe penalties for government employees who disclose information gained in the development of waste reduction programs.

Protection for Consumers of Recycled Materials

There is a general suspicion about the quality of products developed through the recycling of hazardous wastes. In some cases an inferior product may be produced. In many, however, the quality is as good as the original product.

A study which examined the recycling of hazardous wastes in Ontario concluded (Adamson, 1984) as follows:

> "The Canadian Waste Materials Exchange, an information clearing house for prospective buyers and sellers of waste estimates that about one half of unsuccessful exchanges are due to technical problems. These include problems with the quality of the waste listed."

If this is a barrier to recycling, legislation could be developed to allow certification of recycled products or to require vendors to provide protection for purchasers of these products.

8.6 Development of Specific Programs for Waste Minimization

A survey of administrators in each province suggests that waste minimization is a goal of hazardous waste programs, but that limited staff and increased duties in relation to monitoring hazardous waste has made it difficult to achieve substantial results in this area.

The introduction of new legislation provides an opportunity to review programs with industry and find new solutions to old problems. However, without knowledgeable staff to work with waste generators and communicate the goals of the programs, new regulations can appear as harassment and an added burden. Such a perception could discourage the innovation which is required to implement waste minimization programs. For example, the U.S. introduced the Resource Conservation and Recovery Act in 1976 to regulate the disposal of hazardous wastes. Under the Act, strong provisions were made for recycling of wastes as one solution to the problem. However, that message apparently was lost in the Environmental Protection Agency's campaign to bring hazardous waste regulation under control. A participant in the recycling business observed (Palmer, 1982) that:

> "After the regulations were published in late 1979, the EPA sponsored a six-month campaign of terror . . . in which it sponsored hundreds of seminars and symposia around the country where it scared the pants off of businessmen with threats of the penalties that could be applied if they did not scrupulously ship off their hazardous wastes to an approved landfill. I can't tell you how much business my company and other recycling companies lost due to the insistence . . . that every drop of their wastes had to go into a dump."

A waste minimization program will only be effective where regulators are intimately acquainted with the industries involved and can develop a combination of specific incentives and barriers to obtain the desired results. It has been observed earlier in this report that one of the barriers to recycling is the initial effort and cost that must be expended by generators of hazardous waste to move towards waste minimization. The technology involved tends to have high capital costs, but low operating costs. In contrast, disposal tends to have low capital cost, but high operating and maintenance costs.

A direct analogy can be made to the effort required by regulators. A waste minimization program would likely initially require a significant effort by staff to assess the industries involved and develop an effective approach. In the long term, however, few staff would be required to maintain the program and there would be tremendous benefits as a result of the reduced production of hazardous wastes.

In contrast, a program which focusses on disposal will require less staff initially (apart from registration etc.) but will require an increased ongoing commitment and will not be as effective in reducing the long-term problem.

A survey of provincial environment ministries indicated that few have staff which are currently designated to promote waste minimization and those that do have staff have an inadequate number to do the job effectively.

It is recommended therefore that each province establish a waste minimization program with staff allocated to develop industry specific regulations and to administer grants and loans for waste minimization.

8.7 Allowances for Small Generators

The provinces which have developed comprehensive hazardous waste legislation have set the threshold amounts quite low. As a result, many small generators, which were unregulated in the past are now treated in the same way a major generator of hazardous wastes.

This approach has been taken to ensure that all hazardous wastes are properly regulated and to address the problem caused with uncontrolled landfilling by small producers. However, a number of administrators have commented on the increased amount of paperwork required to regulate the small generators. Quebec is now considering exempting generators with less than 20 employees from its manifest requirements to address this problem.

A preferable approach would be to continue to impose the same requirement on large and small generators, but to recognize the difference in capital costs and staff time that a small generator can allocate to a waste minimization program. In particular, a subsidy or grant program could be developed and specific staff time allocated to assist small generators seeking alternatives to disposal.

It is recommended that special regulatory provisions be made for small generators which do not have the resources to develop waste minimization programs.

8.8 Summary of Legislative Barriers

Initiatives have been taken by both the Federal and Provincial Governments to regulate hazardous wastes. These initiatives have been directed towards increased control over disposal and transportation, which has provided some indirect incentive for waste minimization. As well, some jurisdictions have reduced the regulatory requirements for recyclers of hazardous wastes.

Although regulators in all provinces expressed interest in waste minimization, few staff had been allocated for this purpose. Several of those interviewed considered the question of waste minimization to be strictly economic, "if it will make money, it will be done".

The analysis conducted in this report suggests that there are a wide range of barriers, which act as a disincentive to waste minimization. An effective program will therefore require a combination of a clearly articulated goals on the part of government, combined with industry-specific regulations and appropriate financial assistance and the regulatory staff to back up government commitment.

9.0 CONCLUSIONS

The preceding report has examined the factors influencing hazardous waste generation and the means by which quantities of hazardous waste requiring treatment or disposal can be minimized. In addition to traditional waste recycling, the report includes an analysis of other waste recovery and reduction processes. We have identified many barriers to the recycling and reduction of hazardous wastes, under six major categories:

- economic factors;
- technological factors;
- legislative factors;
- institutional factors;
- attitudinal factors;
- informational factors.

The major constraints to hazardous waste minimization appears to be economic, although, as better information is becoming available in the U.S., a strong case is being developed for the profitability of waste minimization.

We have ranked the barriers to recycling of hazardous waste with the results shown in Table 9-1. This ranking was achieved as follows. Each of the project team members was asked to rate the six major categories of barriers on a scale from 0 to 10. The mean of these ratings were then used to weight the ratings for each barrier identified. The second step was to rate the various barriers within each category and, using the weighting factor for categories, assign an overall ranking for each barrier. Finally, rankings were normalized and each barrier was located on the chart in relation to all other barriers.

The most important barriers to recycling of hazardous waste are economic in nature. These barriers are related to the following:

- lower cost disposal alternatives;
- high risk investment with low payback;
- small volume of raw material and market for recovered waste.

These items are all inter-related. Thus, the investment uncertainty and potential payback could be improved if a larger volume of hazardous waste was made available for recycle. A larger volume of waste would be available for recycling if conventional wastes disposal methods (e.g. landfills) were not subsidized, providing unrealistically low prices. Market prices for recycled materials becomes more important as the fraction of recycled hazardous waste increases. The current study did not evaluate this hypothetical situation.

These barriers may become less significant in the future as large corporations undertake more thorough analyses of all alternatives for hazardous waste management. This analysis will include factors for long-term liability and its impact on financial stability. As reported above, many companies are finding that waste reduction, recovery and recycling may be more profitable than waste disposal. These companies are including off-site recycling in their analyses.

The second most important group of barriers are related to attitudinal and economic factors. The lack of direct economic incentives for investment in hazardous waste recycling facilities is considered to be an impediment to investment, thus construction of the facilities. There is an inherent distrust of the quality of recycled materials, in general, which applies to hazardous waste. This barrier will gradually be overcome as the industry can demonstrate that their products can offer significant advantages to those of virgin products. The oil recycling industry has experienced the same attitudinal barriers. The cost of manufacturing virgin materials is often less than the cost to recycle. Besides the economic incentives given to virgin materials, virgin materials are produced in quantities providing an economy of scale not available to recycled materials. Certain recycling processes may be less costly than production of virgin materials, particularly as the volume of recycled material increases.

Barriers which were found to be of least importance include:

- non-availability of off-site technologies;
- alternative technologies competing for the waste;
- lack of appropriate legislative mandates;
- definition of hazardous waste;

- ineffectiveness of waste exchanges;
- vertical integration of large companies generating hazardous waste.

These barriers do not affect the recycling of hazardous waste significantly.

There is a major opportunity to implement a national hazardous waste minimization plan which will effectively reduce the quantities of hazardous waste requiring treatment and disposal. There is also an opportunity to avoid many of the criticisms and difficulties encountered by the U.S. EPA concerning hazardous waste management strategy. In the U.S., although waste reduction is stated as the option of preference for hazardous waste management and secure landfill the option of lowest priority, the U.S. EPA encourages disposal through legislation, public information and economic incentives. Setting waste minimization as a priority can be achieved through a series of actions and policies related to the economic, attitudinal, technological, informational, legal and institutional barriers. The Recommendations section of this report provides a skeletal outline on how this might be achieved.

Table 9-1

RANKING OF BARRIERS TO RECYCLE OF HAZARDOUS WASTE

Economic	Attitudinal	Technological	Informational	Institutional	Legislative
♦ Current cost of treatment, transport & disposal. ♦ Investment risk; payback uncertainty. ♦ Lack of volume markets.	♦ Fear that recycled wastes are unreliable, inconsistent.	♦ Waste quantity not suited to available technologies. ♦ Waste composition not suited to available technologies. ♦ Suitable technology unavailable; yields inadequate product. ♦ Technologies are highly waste stream specific. ♦ Recyc. technology may not be compatible with prod. process. ♦ Recyc. is not the most efficient waste reduc. technology for some wastes. ♦ Alternative technologies compete favourably for waste. ♦ Off-site technologies not available.	♦ Lack of available info. on potential returns of recycling. ♦ Lack of info. on economic incentives. ♦ Lack of technological info. on recycling methods and applicability. ♦ Lack of info. to public on value of recycling in haz. waste reduction. ♦ Lack of info. on availability of audits, exchanges, info. programs.	♦ Industry age and type. ♦ Company size and resources. ♦ Lack of commun. between production line & management. ♦ Existing waste management practices. ♦ Prod. quality & raw material procurement specifications. ♦ Lack of knowledge re wastes generated or products used. ♦ Fear of divulging proprietary info. ♦ Vertical integration of industries. ♦ Ineffectiveness of waste exchanges in establishing new markets for haz. wastes.	♦ Inadequate/inconsistent monitoring/enforcement of existing standards. ♦ Lack of onus for industry & commerce to recycle. ♦ Lack of legislative incentives/disincentives. ♦ Protective provisions for virgin materials, waste purity, product confidentiality and liability. ♦ Implication of inadequate pollution control standards. ♦ Establishment of liability for haz. wastes. ♦ definitions of hazardous waste. ♦ Lack of appropriate legislative mandates.
♦ Lack of adequate incentives (tax breaks, grants, subsidies, low interest bonds, favourable fee structures. ♦ Low current cost of virgin materials. ♦ Cost of implementing recycling practices.	♦ Pollution control not financially productive. ♦ Fear that recycled material will lower perception of product quality. ♦ Potential liability for recycled mater'l. ♦ Desire to uphold traditional practices. ♦ Fear or divulging proprietary information.				

10.0 RECOMMENDATIONS

Recovery and recycling is only one of several means to reduce the quantity of hazardous waste requiring treatment and disposal. This report has identified and discussed several ways to stimulate reduction of hazardous waste including:

- direct in-process recovery, recycle or re-use;
- waste stream segregation, recovery and recycle;
- waste stream recovery and recycle without segregation of waste streams;
- raw material substitution;
- product reformulation to remove or reduce sources of hazardous waste;
- improved housekeeping practices;
- process or equipment redesign.

We have several recommendations for actions and incentives to achieve overall waste reduction. These recommendations can be most effectively implemented if efforts are concentrated in those regions of the country and in those industrial sectors which generate most of the hazardous waste. Previous inventories in Canada, the U.S. and other parts of the world indicate that more than 90% of hazardous waste is generated in five sectors: chemical and allied products, refined petroleum and coal products, primary metals, fabricated metals and rubber and plastics products. Theoretically, reduction of waste generation rates in these sectors should provide the most effective approach. The following recommendations should be applied in all industry sectors, but initial efforts should be concentrated on industries in the five sectors identified above.

Our primary recommendation is that **a National Hazardous Waste Minimization Plan be developed to provide support and direction to the CCREM policy to reduce quantities of hazardous waste for treatment and disposal.** The national plan should address all aspects of waste reduction, including:

- technology and technology development;
- economic incentives;
- institutional incentives, policies and cooperation;

- legislative approaches;
- public education and training;
- projects in conjunction with industry to demonstrate viability and profitability for hazardous waste minimization.

The plan should be endorsed by both federal and provincial governments, and should be funded at a level which will enable effective implementation.

As a corollary to the primary recommendation, the following should be considered elements to be included in the national plan. Several of these recommendations can be implemented whether or not a national plan is implemented.

We recommend that a set of goals and objectives be established and agreed to as a pre-requisite to the development of a national plan. The goals and objectives should include a time period to achieve pre-determined reductions in waste requiring treatment or disposal within specific industry sectors. Priorities should be established for the types of hazardous waste to receive primary attention based on regional economies, pollution control requirements and other factors. For example, corrosive wastes may present a major headache in certain regions. Efforts could be focussed on finding the appropriate technologies to reduce the quantity of corrosive wastes generated in those regions.

We recommend that CCREM establish and encourage the implementation of the necessary policies and programs to overcome the major barriers to recycling and reduction of hazardous waste generation rates. Further investigation of available means to improve the competitive cost with alternate disposal methods, increasing volumes of waste available for recycling and reducing the investment risk for recycling should be undertaken as a priority. At the same time, effective approaches to changing attitudes regarding the quality of recycled materials must be identified. The range of re-sale prices for recycled materials and their effect on the balance between waste disposal and waste recycling is an important variable requiring further analysis.

We recommend that steps be taken by CCREM to establish procedures and protocols for industry to implement waste minimization within each facility.

The procedures should include methodology to complete hazardous waste audits, summaries and technical details for process modifications, raw material substitution or recycling of wastes and analytical techniques to demonstrate the feasibility of the most promising options. Many of the successful elements could be borrowed from the U.S. EPA waste minimization program or the U.S. OTA waste reduction program. Both programs offer many constructive approaches which are both economically and technically viable. The most effective means to stimulate these programs in Canada may require additional information and analysis.

We recommend that technology transfer and technology development be included in each province to promote hazardous waste minimization. The technology transfer component should include as a minimum the following elements:

- a series of information seminars outlining the opportunities for waste reduction;
- toll-free telephone services to assist generators in finding methods to deal with hazardous wastes; (To be most effective, the option to maintain the anonymity of the generator should be included.)
- on-site visits to provide additional assistance when the telephone advice is not sufficient;
- in-plant seminars or video tapes to assist companies in making their employees aware of practices which may lead to generation of hazardous waste;
- a specific program to assist small generators including provision for financial assistance in the form of forgivable loans or other such incentives;
- separate training for conducting audits of facilities and identification of waste reduction opportunities.

The technology development component should be structured so that industry is encouraged to undertake the necessary research and development for techniques or processes which are unconventional, but offer significant advances, if successful. Technology development efforts should be concentrated in manufacturing or with waste generators.

We recommend that several projects be undertaken or sponsored by government to demonstrate the viability and profitability of waste minimization to industry. The projects should include all facets of waste minimization including:

- planning and organization (management commitment, program goals and project team);
- preliminary preparation (waste stream identification, process and facility data, priorize waste streams for assessment);
- assessment of facility (site inspection, list and rank options, identify options for feasibility analysis);
- feasibility analysis (technical and economic assessments, select profitable options);
- implementation of selected options (justify required expenditures, equipment modification/installation, implementation and evaluation).

This type of demonstration project will require the cooperation and assistance of industry and of government operated facilities. It will also require substantial technical and managerial assistance outside of government.

We recommend that the National Plan and/or associated programs concentrate efforts in terms of geographic regions, industry sectors and possibly specific industries where hazardous waste minimization can be most effective. Efforts should be targeted at those regions and industries which are generating recoverable hazardous wastes at high rates or where risks to public health and the environment are high.

We recommend that appropriate economic incentives and financial assistance be made available to industry for waste minimization programs. These incentives and assistance programs should be available to and apply to companies or individuals wishing to establish off-site recovery and recycle facilities. Careful scrutiny of market plans, waste supply and feasibility studies is recommended prior to advancing public funds for these projects. The assistance and incentives can include:

- direct subsidies, grants or interest-free loans;

- indirect subsidies such as favourable taxation policies or disincentives of specific activities which are not conducive to waste minimization;
- clear, strong policies by government encouraging waste minimization.

Several programs for financial assistance are currently available to proponents for a variety of economic development schemes. However, none of these are specifically designed or targeted at hazardous wastes or facilities to manage these wastes. We suggest that existing programs be amended to provide assistance for development of hazardous waste recovery and recycle facilities.

We recommend that governments work closely with senior corporate management to ensure that hazardous waste minimization is a priority at all corporate levels. In the recent past, major companies have been working closely with governments to improve their performance on environmental issues. One example of these efforts is the Community Awareness Emergency Response (CAER) programs and plans prepared by many companies across Canada. Similar cooperation and action is required by companies to ensure that hazardous waste requiring treatment and disposal are minimized. Senior management should be strongly encouraged to undertake at least the following actions:

- develop corporate policies which require management at all levels to identify and implement economically viable opportunities for hazardous waste reduction;
- establish a mechanism which will ensure that the hazardous waste minimization policies are implemented throughout the company;
- ensure that capital resources are available to implement viable hazardous waste reduction measures;
- provide training and information programs to ensure that there is a corporate-wide awareness of the need to minimize hazardous waste generation;
- encourage research and development to find innovative methods to reduce hazardous waste.

Both government and industry will benefit from programs such as this. In addition to reduction of hazardous waste, and the reduced costs associated with

reduced waste quantities, greater public confidence will be gained as waste minimization programs are implemented.

We recommend that national policies, regulations and strategies be developed to encourage waste minimization and recycle as a first option. Specific initiatives which should be considered include:

- provide sufficient staff and funds to effectively enforce existing and future legislation governing the management of hazardous wastes; (The provincial agencies should enforce the legislation aggressivley).
- wastes designated for recycle, recovery or other waste minimization process should not be excluded from regulations, but there should be specific allowances made for storage, transportation and other handling of these materials;
- registration of hazardous waste generators would be required in each province, with sufficient staff and funding to ensure compliance with the requirements;
- disposal of hazardous wastes to sanitary landfills or to sanitary or industrial sewers should be prohibited (where such provisions do not already exist);
- dilution of hazardous wastes to avoid or evade regulation must be prohibited in all jurisdictions, with severe penalties for offenders;
- legislation to protect the confidentiality of information related to recycling or waste minimization and to protect the ultimate consumer of recycled wastes should be considered;
- each province should establish a waste minimization program with staff allocated to develop industry specific regulations and to administer grants and loans for waste minimization;
- special provisions should be made for small generators which do not have the resources to develop waste minimization programs.

We recommend that a hazardous waste management strategy be developed and implemented as policy by the federal government and each of the provincial governments. This policy should rank waste management options in terms of preferred approaches. One such prioritization could be as follows:

- raw material substitution or product reformulation to eliminate hazardous waste generation;
- waste reduction by in-process recovery, recycle and/or re-use;
- recovery and recycle with or without segregation (on-site or off-site);
- waste separation and concentration;
- waste exchange through clearinghouses or directly between generator and consumer;
- energy recovery;
- treatment and/or incineration to destroy, detoxify or neutralize wastes;
- disposal to secure landfill or deep well injection.

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